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Reports
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Design and comparison of quantitative alternative future landscapes scenarios for the Bitterroot Front Area

Design and Compare Quantitative Desired Future Scenarios for the Bitterroot Front Area.

Final Contract Report for RJVA Agreement No. 03-JV-112222052-096

R. Pfister, M. Twer and J. G. Jones
December 16, 2005

(Note: The format of this report addresses the key points of the RJVA and revisions directly and attaches detailed reports as Appendix items.)

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Design and Compare Quantitative Desired Future Scenarios for the Bitterroot Front Area.

Final Contract Report for RJVA Agreement No. 03-JV-112222052-096

A. PURPOSE: (from RJVA)

1. The purpose of this agreement is to develop an efficient landscape assessment and analysis process for a large landscape as a foundation for future ecosystem management planning and implementation. This process will be tested using existing data and information for the Bitterroot Front Landscape (441,000 acres).

C. THE FOREST SERVICE SHALL: (from RJVA – accomplishments in **(bold):**

1. Collaborate with the Cooperator in the preparation of a mutually acceptable work plan. **Completed April 30, 2003**

2. Provide guidance, advice, consultation, and co-leadership essential to the satisfactory accomplishment of this agreement.

Rocky Mountain employees J. Greg Jones, Jim Chew, Chris Stalling, Robert Ahl, and Kevin Hyde have all contributed to this joint effort.

3. Provide the current GIS database for the study area in a CD-ROM or other data transfer link.

Robert Ahl provided a CD-ROM database for the study area. Total area is 467,481 acres, according to the GIS data layer. An updated database to represent the 2000 and 2003 fires was provided on 10/23/03 (Appendix A, p. 23). An apparent error in habitat type group assignment was resolved by reassignment as discussed in Appendix A, pages 24-25.

4. Provide recent versions of SIMPPLLE for the study area.

Provided by Chris Stalling and Jim Chew. Jim Chew also provided several sets of new Bitterroot specific pathways and five modifications of the Insect/Disease and Firetype modules following review of output from the original SIMPPLLE runs (Appendix A, p. 24).

5. Provide a representative sample of available stand inventory data (tree lists) for running the Forest Vegetation Simulator to make comparisons with appropriate successional pathways in the SIMPPLLE model.

Bitterroot FIA database provided in summer of 2003 by Jim Chew. Additional information provided by Sue MacMeeken (Bitterroot National Forest) and Renee Lundberg (Helena National Forest). Ken Brewer and Renate Bush provided current R-1 stand classification protocols. The computer program for assigning FVS output to R-1 Stand Types has been under development by the Northern Region for the last two years. Renata Bush and Renee Lundberg provided us with classification output for the Bitterroot FIA/FVS dataset in July 2005.

6. Provide fire history data for the Bitterroot Front Landscape.

A landscape assessment notebook for the Bitterroot Front was provided by Bitterroot National Forest at beginning of project (Bitterroot National Forest 1999). Additional fire history data from the Bitterroot National Forest was provided by Jim Fears, Bitterroot National Forest, Hamilton, May 03, 2004.

7. Assist in conducting runs of SIMPPLLE as mutually agreeable.

Chris Stalling and Jim Chew trained Martin Twer to run SIMPPLLE on the Bitterroot Front database. Jim Chew has provided continuing consultation on interpreting results of SIMPPLLE runs.

D. THE COOPERATOR SHALL: (from RJVA – accomplishments in **(bold):**

1. Perform the following tasks:

a. Analyze and prepare summaries of Existing Vegetation and Historic Vegetation using the Ecosystem Diversity Classification Framework.

Martin Twer completed summaries of the Existing Vegetation Conditions in EXCEL and also created Pivot Tables for a variety of summary formats. These and a summary of Losensky Historic Vegetation were used for Landscape Team meetings. They are documented in Appendix A, p. 19-23 (SIMPPLLE/Losensky crosswalks) p. 31-47(existing conditions) and p. 52-56 (existing/historic comparisons). The Historic fire dataset for the Bitterroot Front landscape is presented and discussed in Appendix B.

b. Predict how the vegetation on this area will likely change over time for the "No Action" scenario both with and without fire suppression utilizing the SIMPPLLE model. Compare the wildland acres burned in these "No Action" simulations with data from the wildland fires experienced in recent past decades, including acres burned by fire intensity classes and fire-size distribution.

Martin Twer completed SIMPPLLE (v2.2) runs, 12 cycles @ 10 years @ 30 runs, with and without fire suppression on: 1) the original database, 2) on the 10-23-03 database, and 3) after obtaining the 2004 pathway updates from Jim Chew (Appendix A, p. 48-51).

Wildland acres burned in these "No Action" scenarios were presented in a separate report (with accompanying posters) to the BEMRP Landscape Team in March 2004. Comparison of wildland acres burned in the "No Action" scenarios with historic wildland fires in the Bitterroot Front Area are presented in Appendix B.

c. Develop several quantitative Desired Future Conditions (DFC) (Restoration, Biodiversity, Sustainable Wood Production and an Integrated Desired Future Condition) and treatments required by time periods to move from existing conditions to Desired Future Conditions.

The Ecological Restoration, Ecological Diversity, and Sustainable Timber alternative future condition scenarios are presented in p. 51-76 in Appendix A. A comparison of the alternatives is provided in p. 76-82 and an Integrated Scenario is presented in p. 82-87 in Appendix A. Treatments required by time period to move to Desired Future Conditions have not been estimated.

d. Collaborate with the Rocky Mountain Station to select a representative sample of available stand inventory data (tree lists) and run the Forest Vegetation Simulator to make comparisons with appropriate successional pathways in the SIMPPLLE model.

Jim Chew provided the Bitterroot FIA database in summer of 2003. Additional information was provided by Sue MacMeeken (Bitterroot National Forest) and Renee Lundberg (Helena National Forest). Ken Brewer and Renate Bush (R-1) provided current R-1 stand classification protocols. Programmers at Forest Management Service Center, Fort Collins fixed the canopy cover algorithm in FVS.

Martin Twer completed FVS runs (Suppose v1.16), 12 cycles @10years, starting 2000, including Canopy Cover Extension, Structural class variables and Event Monitor.

Crosswalk of FVS output to the R-1 Classification currently used for SIMPPLLE (Chew and others 2002) presented complications. Many of these problems and some suggested solutions are documented in the Northern Region Vegetation Council Classification Workshop Report (Northern Region 2003). The computer program for assigning FVS output to R-1 Stand Types has been under development by the Northern Region for the last two years. The algorithms for the computer program were provided to us by R-1 in February 2005 (Northern Region 2005). Attempts were made in the spring of 2005 to run their classifier program on our FIA/FVS dataset, but were unsuccessful with our computer systems. The dataset was provided to Renata Bush and Renee Lundberg and they provided us with classification output for the Bitterroot FIA/FVS dataset in July 2005. The results of this exercise are documented in Appendix C.

The following tasks were added in Amendment Two in August 2004:

e. Summarize the general differences and similarities among the alternative DFC's in terms of resource effects, treatment types and acres, volume removals, residual volumes, and risk of various disturbance processes over a 100-year time period.

Comparisons of the alternative DFC's are provided on p. 76 –81 and with the Integrated alternative described on p. 81-87 in Appendix A. General differences and similarities are described, but treatment types/acres and volume removals were not addressed. These would likely be more appropriately addressed by using MAGIS. Estimating risk of various disturbance processes over a 100-year time periods would require running SIMPPLLE at various post-treatment time steps, once the treatments had been prescribed for specific time periods and the stand condition inventory adjustments had been made. A simplified implementation schedule was developed by hand for one alternative in the Bair Landscape Assessment (Pfister and others 1999) but was not attempted for the Bitterroot Front Landscape.

f. Discuss potential problems for implementing Desired Future Condition (DFC_ Scenarios relative to unique conditions and management constraints for the study landscape.

Some of the problems for implementation of any of the Desired Future Condition Scenarios on such a large landscape of contrasting land management

goals are discussed on p. 87-90 in Appendix A. Different DFC scenarios may be appropriate for individual smaller landscapes within the Bitterroot Front.

g. Collaborate with the Rocky Mountain Station to use MAGIS to develop space/time scenarios for implementing selected alternative Desired Future Conditions with specified resource objectives and operational feasibilities.

This potential opportunity did not materialize during the time of this RJVA.

h. Run SIMPPLLE for the alternative treatment schedules developed by MAGIS or by other means and analyze the results.

This potential opportunity did not materialize during the time of this RJVA.

i. Participate with the Forest Service in research/management meetings and communications pertaining to this work.

Participated in meetings as requested or scheduled. Prepared volume summaries by stand type classes to compare with the volumes by types being used within MAGIS. Further work on generating volume estimates for stand type classes should require standardization of the stand type variables, especially for Size Class.

2. Collaborate with the Forest Service in the preparation of a mutually acceptable, detailed work plan, submit a copy of the plan to the Forest Service by April 30, 2003, and conduct this study in compliance with the work plan as well as the provisions of this agreement.

Completed April 30, 2003

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Design and comparison of quantitative alternative future landscape scenarios for the Bitterroot Front Area

By

Martin Twer

Dipl., University of Muenster, 2001

Presented in partial fulfillment of the requirements for the degree of

Master of Science in Resource Conservation

The University of Montana

May 2005

Approved by:

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Committee Chair

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Dean, Graduate School

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Date

Abstract

Twer, Martin M.S., May 2005 Resource Conservation

Design and comparison of quantitative alternative future landscape scenarios for the Bitterroot Front Area

Committee Chair: Robert D. Pfister

Management planning for public lands often reaches a gridlock situation due to diverse values and goals of stakeholders. New approaches to public land management planning have been suggested in the Bitterroot Ecosystem Management Research Project. The Bitterroot Front landscape of 467,000 acres has been selected for several research/demonstration studies on landscape assessment and use of models to facilitate landscape-level planning. This thesis is focused on the development of alternative quantitative desired future condition scenarios as a tool for gaining shared perspectives on alternative future conditions.

Four primary alternative quantitative future management scenarios were initially created for a 120-year planning horizon. The alternatives focus on 1) No Action, 2) Ecological Restoration, 3) Ecological Diversity and 4) Sustainable Timber Production. Two "No-Action" scenarios (with fire suppression and without fire suppression) were created by projecting Existing Conditions 120 years into the future with the SIMPPLLE model. Alternatives 2, 3 and 4 were based on interpretation of available literature relevant to each primary goal and establishing a quantitative target condition for 120 years in the future. The outcomes of the simulated and designed scenarios are then compared with existing conditions and with each other.

Graphical summaries visually demonstrate the quantitative differences (and similarities) among outcomes based on competing ideas for how to manage forest landscapes and elucidate the relationships among the different stated goals. With differences among desired future conditions much less than one would anticipate it appears that a consensus might be feasible among stakeholders.

A final Integrated Alternative was developed illustrating a possible compromise among the competing alternatives and seeks to satisfy the identified multiple concerns. The overview of alternative scenarios provides a shared perspective unique to each landscape and the major local management issues. A suggestion of an Integrated Alternative provides a target vision and landscape context for planning of smaller areas within the large area. The common GIS database can be used to address opportunities and constraints for smaller areas and further analyses with the MAGIS model thus helping break up the gridlock situation and making future planning and implementation of the planned management activities possible.

Acknowledgements

I would like to express my appreciation, first to my advisor Robert Pfister, who initially provided me the opportunity to continue my scientific and educational career here in Missoula. Throughout the process of this study he provided a valued balance of positive comments and critical review. He and his family gave me a home away from home and the safety of a family when needed.

Further to my committee: Carol Brewer, Jack Ward Thomas, and Hans Zuuring. Their support and patience were indispensable.

I would also like to thank those who provided funding, assistance, and ideas both in the early and late stages of this project, including Greg Jones and Jimmie Chew, and Jonathan Haufler for advice.

I am grateful for my parents, who made it possible for me to study and accepted and supported my decisions and ways.

Last but not least, I would like to thank my friends and fellow students for their help and support.

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Introduction

Background

The basic difficulties for today's public land management are the diverse values and goals of stakeholders. Without consensus on goals, planning and attempted implementation become exercises in futility. As a result, 'no-action' becomes the de facto management activity. This problem becomes particularly apparent in Montana and the western United States, where a high proportion of forestland is in public ownership. The Ecosystem Management approach (Meffe et al. 2002) offers some promise of reaching a consensus on public lands in western Montana to implement the practice of sustainable forest management. Implementation of ecosystem management concepts requires landscape-level approaches to assessment and planning that provide participants with a shared understanding of historic, existing and possible future conditions. The relationship of existing vegetation to desired future conditions needs to be quantified by examining vegetation development pathways in order to enable a shared understanding of the consequences of alternative management strategies.

The increasing human use of land and exploitation of natural resources on the one hand and the increasing awareness of its consequences for ecosystems and eventually humans on the other, have finally led to a more conscious perception of nature e.g. its complexity, and its limits, by scientists, politicians, natural resource managers, and the public. It has been recognized that 'arrangements' have to be made to provide protection for the environment and, at the same time, provide resources for growing human populations. A holistic understanding of natural processes and human – nature interactions is crucial to achieve this.

The view of landscape ecology as a basis for natural resource management has its primary focus on 1) spatially heterogeneous areas, 2) material and energy fluxes among landscape elements, and 3) human actions and responses to, and their reciprocal influence on ecological processes (Risser et al., 1984). Landscape ecology, with the concept of connectivity and as

chorological studies describing spatial and topological relationships, could lead to a better understanding of landscape functions (Zonneveld, 1990), with ecological processes operating at different scales in time and space (Risser, 1987). Observing changes in landscape characteristics over a longer period of time provides us with insight into landscape dynamics. To understand the dynamic nature of landscapes and to offer a reference for assessing current patterns and processes, historical perspectives are also useful (Swetnam et al., 1999).

Ecosystem management concepts and landscape ecology perspectives should provide a foundation for sound land and resource management planning, decision making and implementation. To have a platform to start from, basic data are needed; a formal landscape assessment provides this foundation. To understand whether certain landscape features are attributable to environmental factors or a disturbance process at some time in the past, the interplay of environment and human history has to be considered (Zonneveld, 1990).

Furthermore, the matter of scale is important for a rational assessment, as a certain management planning task focuses on a specified scale. Consequently, on the one hand, processes and patterns occurring on much finer scales are not always perceived due to filtering or averaging effects. On the other hand, those occurring on much broader scales may be overlooked simply because the focus is within a smaller landscape unit (Risser, 1987). Turner et al. (2001) describe finer-scale processes as mechanisms that explain landscape dynamics nested within a broader-scale pattern, which limits the potential range or rate processes. The applied landscape simulation model (SIMPPLLE) (Chew et al., 2002) together with the formulation of alternative management scenarios facilitate resource planning at the landscape scale.

The intention of this study is to characterize and assess the existing vegetation conditions of the Bitterroot Front landscape, and to present four alternative management scenarios, joining landscape ecological perspectives with vegetation management practices in the context of an ecosystem management concept. Although this focuses on the biophysical components of

ecosystem management, a supporting network of constraints, permissions and requirements will guide the definition of management goals (Rauscher et al., 2000).

General Guidelines

The Bitterroot National Forest is part of the USDA, Forest Service, National Forest System. Under the "management objective to support industry with raw materials while protecting the amenity values of the Forest", the Bitterroot National Forest Plan (1987) addresses six major issues: timber harvest level, visual quality, fish and wildlife populations, water quality and soil productivity, roadless area management, and recommendations for managing two Montana Wilderness Study Act areas. Current and previous Forest Plans had a limited spatial focus on Bitterroot National Forest lands, considered species diversity at site or stand level, concentrated efforts on National Forest lands and its outputs to dependent communities, and were output-oriented for both amenity and commodity resources (Bitterroot National Forest, 1994). To accommodate the idea of Ecosystem Management (EM) the need for a paradigm shift in the management of the Bitterroot Forest is acknowledged in the Forest Plan Five Year Review (Bitterroot National Forest, 1994): The scope changes from National Forest lands to the consideration of ecosystems on a landscape scale.

Objectives and Goals

The purpose of this thesis is to develop and demonstrate an efficient landscape assessment process for a large landscape as a foundation for future ecosystem management planning and implementation. It will provide part of a landscape assessment of the 467,000-acre landscape of the Bitterroot Front. The study uses an existing GIS database of the Bitterroot Front and will emphasize vegetation conditions through three sub-objectives:

1. Summary and display of the spatial distribution of existing vegetation conditions as a key starting point and benchmark for planning.

2. Development and simulation of four primary alternative future management scenarios: 1) no action, 2) ecological restoration, 3) biological diversity (coarse filter approach), and 4) sustainable timber production.
3. Comparison of alternative future vegetation conditions expected for each scenario.

Literature review

Historic forest conditions

Several authors provide background data on pre-settlement forest and landscape conditions in Montana and the processes that shaped them. Losensky (1997) illustrates quantitative estimates of the historical vegetation of Montana around 1900; Green et al. (1992) describe old-growth forest types of the northern region, while Johnson et al. (1995) present a mathematical approach for simulating natural disturbance cycles and to quantify the effects on forest stands. Historic forest conditions can be estimated by interpreting the fire ecology of western Montana forest habitat types (Fischer & Bradley. 1987). Bonnicksen (2000) provides a broad background on America's ancient forests. Hartwell et al. (2000) recently conducted studies on "comparing historic and modern forests on the Bitterroot Front", while Hardy et al. (2000) provide management guidelines for the "ecosystem-based management in the Lodgepole pine zone".

Inventory and classification of existing and potential vegetation conditions

The inventory and classification of potential natural vegetation conditions is based on Pfister et al. (1977) forest habitat types of Montana. The existing vegetation conditions are classified by composition (cover type), structural stage (size class, canopy cover classes), and vertical structure (layers). These are combined into an ecosystem diversity framework (Pfister & Sweet, 2000). For modeling purposes and analysis abstraction the classification in the landscape model SIMPPLLE (Chew et al., 2002) was used, which employs the Forest Service Region 1 categorization.

Ecosystem management

The entire range of society's values associated with forested landscapes needs to be understood prior to the development of an integrated forest resource management plan (Dewhurst & Kessler, 1999). To "blend the needs of people and environmental values" (Kaufmann et al, 1994), Ruzicka & Miklos (1990) describe basic premises and methods in landscape ecological planning and optimization that strive for the integration of natural resource utilization, nature conservation, and the "creation of an ecologically optimum landscape". Brown (1995) focuses on fire regimes, their spatial characteristics and dynamics and relevance to ecosystem management. Addressing a process for ecosystem management at a landscape scale, Haufler et al. (1996) propose a concept to include the conservation of biological diversity in ecosystem management. Ideas from a recent textbook by Meffe et al. (2002) as well as the concept of multi-goal decision making as described by Kangas (1994) and Rauscher et al. (2000) are incorporated in this thesis.

Patterns and processes in forest landscapes

Literature here will focus on the processes that shape forest landscapes and describe the existing patterns and functions. A background on terminology and functions is provided by basic landscape ecology literature from Forman (1995), Forman & Godron (1984) as well as Risser et al. (1984), defining and describing landscape elements, functions and their relevance to landscape dynamics and interaction on different spatial and temporal scales. Agee (1990) as well as Franklin & Forman (1987) illustrate disturbance process oriented background that focuses on fire cycles and human induced dynamics that shaped forest landscape patterns in the past and presence.

Issues of preservation, restoration, biodiversity and sustainable timber production

This will be the key for defining and designing desired future forest conditions. The restoration aspect will be mainly addressed by the above-mentioned Euro-American pre-settlement conditions, described by Losensky (1997). Fiedler (1996) and Hardy et al. (2000)

focus on the restoration of ecological structure and process, and ecosystem-based management, respectively, as guidelines for the design and restoration of cover type specific future forest landscapes. Haufler et al. (1996) as well as Kangas & Pukkala (1996) display how to include the enhancement and maintenance of biological diversity in managed forest ecosystems. Background on sustainable timber production is provided by Arney (1996) as well as an SAF (1993) publication on long-term forest health and stability (Fiedler, 2002). The Bitterroot Forest Plan (Bitterroot National Forest 1987) provides actual timber harvest volume targets in an effort to sustainably accommodate current and future timber demands.

Uncertainty in decision making and adaptive management

From a wide body of literature available on adaptive management and uncertainty in ecosystem management, a selection is provided to present a background and key concepts. Multiple sources of stochasticity and nonlinearity are the cause for inherent uncertainty in future predictions and models, in regard to ecological systems, climate change and its potential effects, and societal change of values (Clark et al., 2001), among others. To mitigate the negative effects on the accuracy of future predictions, Kangas & Kangas (2004) as well as Bormann & Kiester (2004) address the general need for embracing uncertainty in the process of forest management decision making by acknowledging it and incorporating it as a variable in the process. Walters & Holling (1990) introduce the concept of adaptive management that allows for future management adjustments following unpredictable alterations of landscape parameters, newly available scientific knowledge, or changes in amenity and commodity values. Gunderson (1999) and Meffe et al. (2002) present examples of its implementation and effectiveness.

Methods

Study Area

The study area encompasses 467,481 acres of the Bitterroot Mountain Range or Bitterroot Front as part of the larger Bitterroot National Forest (1,113,700 acres) (Bitterroot National Forest, 1987). It is located in the western part of the Bitterroot River Basin in Ravalli County, Montana, USA, generally west of Highway 93 between the towns Lolo (Lat: N46.76°, Lon: W114.08°) in the north and Connor (Lat: N45.93°, Lon: W114.12°) in the south (see Map 1) (GIS data from Bitterroot National Forest, Jim Fears, 2004). It is bordered by the Montana/Idaho state border to the west and the Bitterroot River to the east. Elevations range from about 3,150 to just over 10,000 ft mean sea level. Slopes range from 0 percent along the Bitterroot River to over 75 percent in some upper portions. Its western section is part of the Selway-Bitterroot Wilderness Complex along the Idaho-Montana state border.

Climate

With its location west of the Continental Divide, the area features a temperate continental climate with Pacific maritime influences, with generally dry/warm summers and dry/cold winters.

The climate data for the valley bottom originates from the weather station near Hamilton at 3530 ft. (Western Regional Climate Center [online]). Mean annual temperature is 45.2 °F, the warmest month is July (66.1 °F), the coldest month January (25.3 °F). Mean precipitation ranges from 0.76 inches in February to 1.75" in May, with an average annual precipitation of 13.54".

Snowfall might occur from September until May. Snow covers the ground from November until March. The average annual snowfall is 36.9" and the maximum snow depth occurs in February with 3.2'.

Average annual precipitation ranges from 11" in the bottom lands along the Bitterroot River to 83" in some high elevation areas (GIS data from Montana Natural Resource Information System [online], 2004).

Map 1. DEM, hydrography and towns of the Bitterroot Front Landscape

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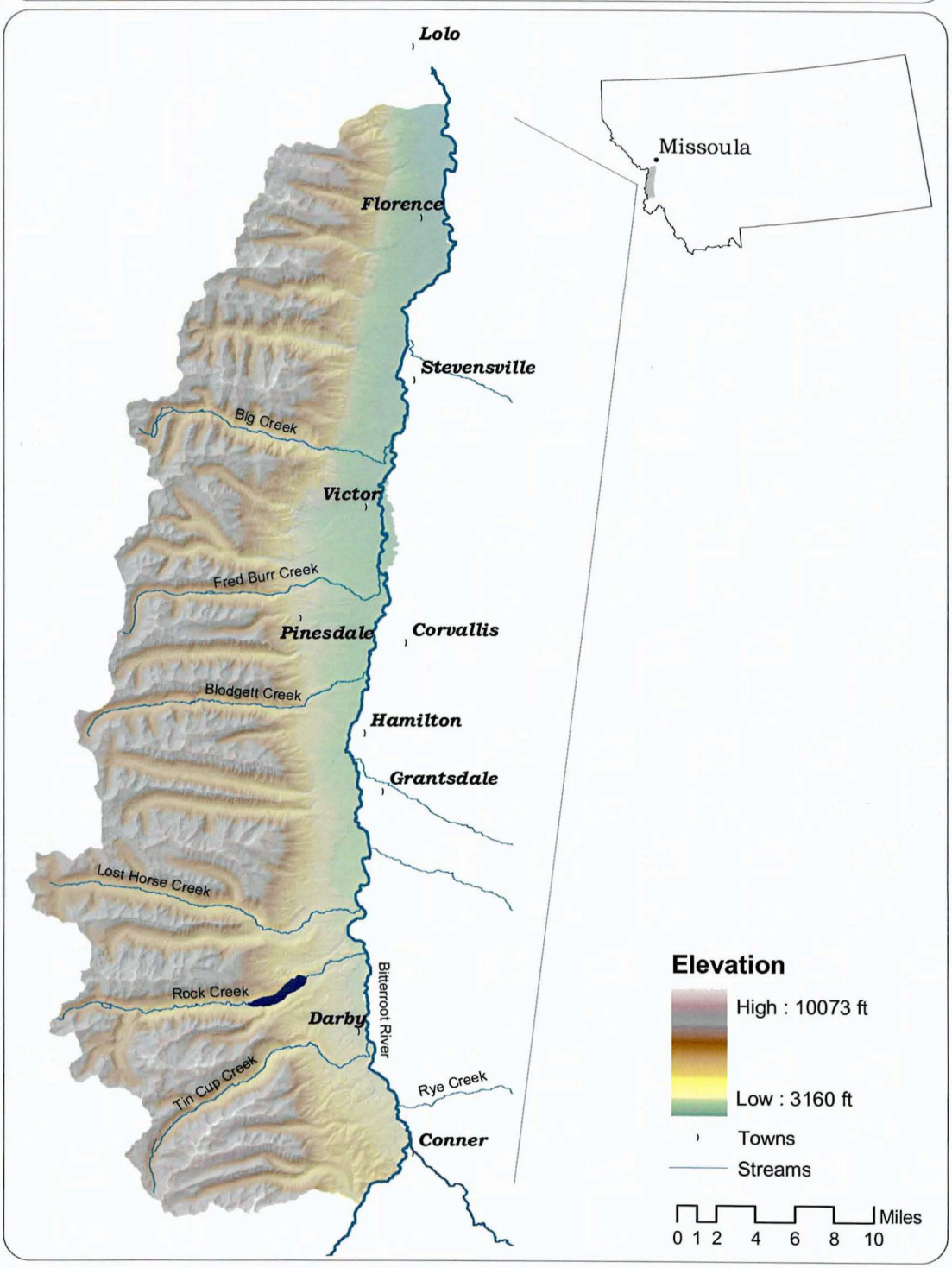

Geology and Geomorphology

The major part of the lowlands in the eastern part of the study area and several of the larger valley bottoms are Cenozoic quaternary alluvium, mainly silt. Rock formations in the western part are largely Mesozoic cretaceous gneissic quartz monzonite. Tertiary gravel in the north and quaternary boulders in the south form the sedimentary fans from mountain streams along the border zone, consisting of Mesozoic cretaceous granitic gneiss, in the foothills between the Bitterroot valley alluvium and the rising rock formations of Idaho batholith and associated masses (GIS data from Montana Natural Resource Information System [online]).

A significant feature is the east-to-west orientation of most major drainages with the high crest of the Selway-Bitterroot Range to the west running in a north-south direction.

Soils

About 50% of the study area is identified as rock outcrop by the 1998 soil survey for STATSGO map units (Soil Survey Staff, 1999) and is not described in detail. Five soil orders are found on the remaining land (Map 2) (GIS data from USDA-NRCS [online], 2004):

1. Inceptisols (27%) (suborders Cryepts and Ustepts) occur along the fringes and embrace the rock outcrop.
2. Spodosols (9%) (suborder Orthods) form an almost continuous belt along the contact zone between the uphill Inceptisols and the
3. Mollisols (7%) (suborder Ustolls) in the northern part of the valley and
4. Entisols (6%) (suborder Orthents) along the banks of the Bitterroot river.
5. Alfisols (suborder Cryalfs), and Aridisols (suborder Argids) occur as small islands in the southern part.

Map 2. Spatial distribution of soil orders within the Bitterroot Front Landscape

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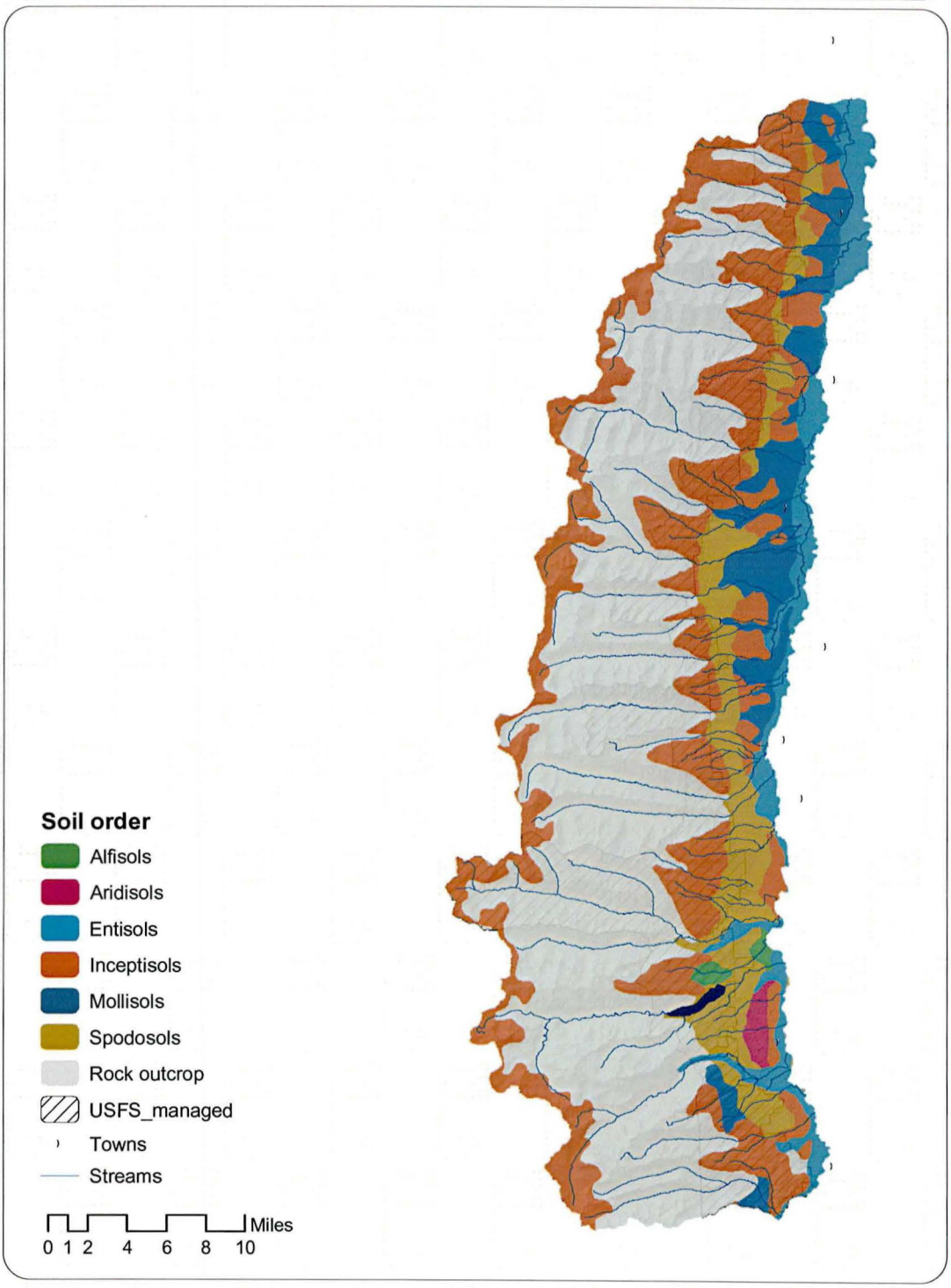

Inceptisols are immature soils usually associated with floodplains, fairly steep slopes and young geomorphic surfaces that exhibit weakly developed subsurface horizons. The naturally infertile soils of Spodosols have acidic properties. Their typical horizon is formed by podzolization, a process that complexes humus with aluminum (Al) and iron (Fe). Entisols are mostly unconsolidated parent material as in large river valleys and associated shore deposits or steep rocky terrain. Alfisols and Mollisols are both mature soil orders with well-developed horizons and high base status. Alfisols are generally found with tree cover, Mollisols are typical grassland soils (University of Idaho, Soil Service Division [online], 2004). Soil temperature regimes are frigid and cryic. Drainage properties are mostly excessive and somewhat excessive along the mountain face and well drained in the valley bottoms.

Vegetation

The predominant natural plant communities range from open old growth Ponderosa pine on the warm and dry lower slopes and valley bottoms, to mixed conifer Douglas fir-Lodgepole pine stands, to high elevation white bark pine/subalpine fir stands and significant amounts of alpine grass land types. Due to its cooler and drier climate, species like western white pine, grand fir, western larch and western red cedar "reach their southeastern limits within the section" (Losensky, 1997).

Historic disturbance and conditions

Periodic occurrence of fire was the major factor shaping the appearance of the landscape by causing natural disturbance and thus manipulating the vegetation cover prior to human settlement (Fischer & Bradley, 1987). Alternating intensity, frequency, severity and size of fires tempered the vegetation differently (Brown, 1995). Depending on climatic conditions, site characteristics, and fuel accumulation, the range varied from light understory burns to stand replacing fires, maintaining a complex matrix and processes in the forest ecosystem (Agee, 1990). Further upland disturbance mechanisms were insects, diseases, wind throws, and flooding in bottomlands (Haufler et al., 1996). The Euro-American settlement era beginning about 1900

changed the forest landscape significantly. The introduction of forest management practices, mainly fire suppression and intensive logging, had major impact on the development of vegetation cover and the overall appearance of the landscape through changes in frequency, intensity, quality, and extent of disturbance processes.

Existing conditions (Landscape Ecology Perspective)

Since landscape level considerations have become increasingly critical for contemporary forest ecosystem management, the description of the existing conditions from a landscape ecology perspective depicts the spatial components that make up the landscape. This perspective provides the background for a holistic approach, guiding sustainable forest management for multiple uses. A popular model for characterizing the landscape elements in a categorical map is the patch-corridor-matrix model by Forman (1995). Definitions for a landscape ecology terminology based on Forman & Godron (1981) are applied in the following text to describe the landscape features of the assessment area.

Patch

In the context of forest management, stand polygons are the basic spatial unit. For the Bitterroot Front, patches are defined by the stand polygons. The polygons were created by natural disturbance, environmental gradients and silvicultural treatments. The visual distinction of the polygons on aerial photographs basically reflects the differences in two physiognomic attributes: cover type and structure type. Therefore, two primary patch types can be identified from the database for the study area: forest, and non-forest or grassland. A total of 18,533 stand polygons are currently identified. The largest patch in the study area is 1,312 acres, the smallest 5 acres, with a mean patch size of 25 acres and a median patch size of 12 acres. About 80% of the areas patches are smaller or equal to 32 acres (Figure 1). Non-forested polygons are generally smaller than forested polygons. Besides size, shape and orientation as critical patch-attributes (Rosenberg et al., 1997) the edge of a patch is another important characteristic that

needs to be considered for several ecological inquiries, such as migration studies and habitat fragmentation, but is not addressed in this study.

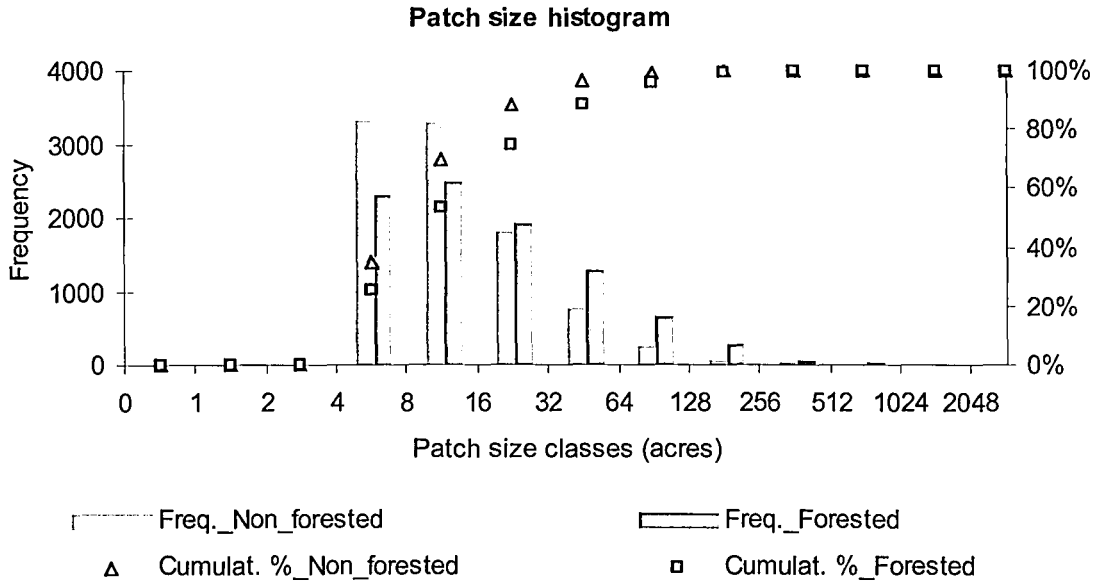

Figure 1. Frequency distribution and cumulative percentage of forested and non-forested patches by patch size for Bitterroot Front Landscape

Grain

Grain describes the average size of a patch. It is a function of landscape diversity or fragmentation on the one hand and the resolution of the inventory on the other. Considering three patch types 'forest vegetation', 'non-forest vegetation' and "barren/ no vegetation" for the assessment area, the grain is judged to be coarse. Splitting up the forest vegetation part into the stand polygons generates a medium grain landscape. A fine grain is represented by the variation of site conditions within a single stand polygon.

Corridor

Corridors, if defined only in terms of shape and spatial context, are narrow strips of land, which differ from the surrounding on either side (Forman & Godron 1986). The function is two-edged, depending on scale and migration needs, serving either as a link between similar patches or as a barrier between them. For the study area roads and stream valleys as well as open

stands function as movement corridors for various mammals. For other animals the same structure acts as a barrier, separating populations and habitats.

Flow

Flows are fluxes and re-distribution of materials and energy across a landscape (Risser 1987). While the roads in the assessment area are two-way flows of humans, animals, nutrients, and plants, drainages like the numerous creeks are one-way flows of nutrients and sediments. In the context of forest management activities this needs to be considered when applying treatments in different upper watersheds since cumulative effects can impact ecosystems further downstream. E.g. the combined sediment laden surface runoff from logging operations in several watersheds, even if below threshold limits and occurring at different times, create accumulated effects on the stream quality in the lower reaches.

Network

Networks describe the entire set of corridors. Roads, glades and watercourses of any size form a complex system of linking landscape elements (Forman & Godron, 1981). They provide a pattern of paths for movement of system components. The most apparent network features of the assessment area are the dendritic stream networks and the irregular road and trail networks.

Matrix

The most extensive and connected landscape element is called a matrix (Forman 1995). Patches and corridors are embedded in the matrix. Three matrices could be determined for the assessment area: The forest matrix on the slopes of the Bitterroot face, the grassland/ prairie matrix in the bottom lands along the Bitterroot River, and the rock outcrop on higher elevations. Within each matrix scattered patches of another type may occur, like forested tracts of land in the valley bottom and open sites in the forested part, caused by natural or anthropogenic disturbance processes, as well as tree and alpine grassland patches in the rock faces resulting from micro site conditions.

Ownership, Administrative Units and Forest Management Zones (FMZ)

The study area has a complex structure of ownership, administrative units and forest management zones. While the lands in the floodplain of the Bitterroot river are mostly private, the majority of the land is under Forest Service administration (Table 1), reaching from the foothills up to the Montana-Idaho state border and forming the major part of the actual Bitterroot Front landscape (Map 3), and is subdivided into 18 management areas (Bitterroot National Forest, 1987). Few parcels are state lands.

Within the Bitterroot the acreage is divided into 44.3% designated wilderness and 30.3% Forest Service "manageable" land, which is further subdivided into forest management zones (FMZ) with approximately 12.2% roadless area, 6.9% roaded area and 11.2 wildland/urban-interface (WUI) (Map 4).

Table 1. Summary of ownership, administrative units, and forest management zones

Ownership	Acres	%	Admin	Acres	%	FMZ	Acres	%
Forest Service	348,778	74.6	NF Wilderness	207,277	44.3	4 - Wilderness	207,277	44.3
			NF Other	141,501	30.3	3 - Roadless	56,901	12.2
						2 - Roaded	32,331	6.9
						1- WUI	52,269	11.2
Private	116,800	25.0	Other	118,703	25.4	0 - None	118,703	25.4
State	1,883	0.4						
USDI	20	0.004						

The analysis and comparison of the study area is limited to the forested polygons of the total area (Habitat type groups (HTG) A2 – G2). Non-forest polygons are identified by unique codes: NF1 – grasslands, NF2A – shrublands, NF5 – alpine, XX1 – agriculture, XX4 – barren, and XX5 – water (Table 2). These are excluded and the area (174,352 acres, 37.3%, 9500 polygons) subtracted from the total area of 467,481 acres. The remaining forested lands of 293,129 acres in 9,033 stand polygons were set equal to 100% for the following analysis and comparisons unless stated otherwise.

Map 3. Ownership distribution within the Bitterroot Front Landscape

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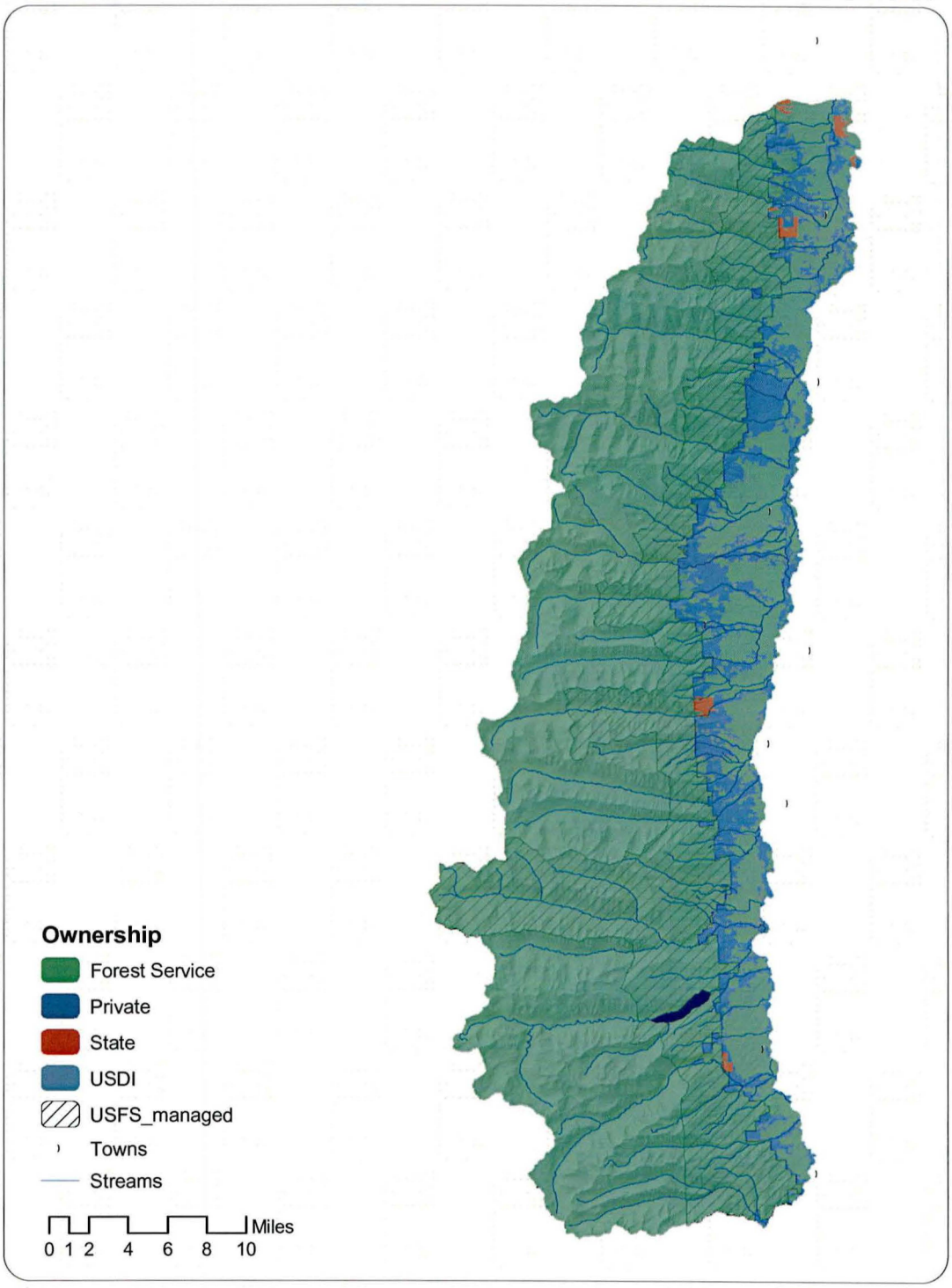

Map 4. Spatial distribution of forest management zones within the Bitterroot Front Landscape

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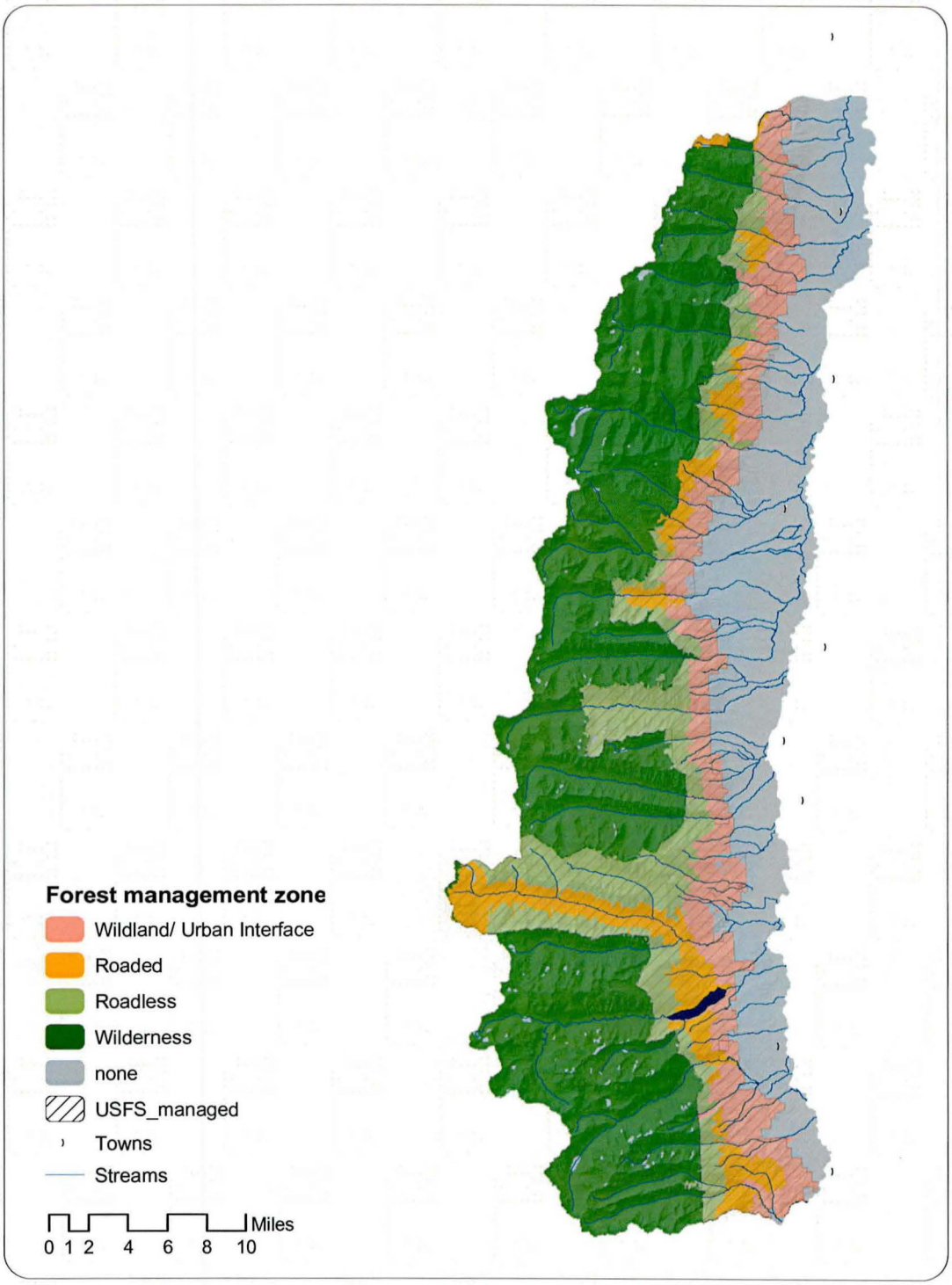

Table 2. Summary of acres by SIMPPLLE non-forest habitat type groups within the Bitterroot Front Landscape

Type code	Acres	%
NF1 – Grassland	23,237	13.3
NF2A – Shrubland	20,372	11.7
NF5 – Alpine	24,684	14.2
XX1 – Agriculture	20,495	11.8
XX4 – Barren	82,339	47.2
XX5 – Water	3,225	1.8
Total	174,352	100.0

Data collection and Analysis

The 467,481 acres of the Bitterroot Front served as the research area. In a first step an existing GIS database was acquired to provide a site description and to display and analyze the existing vegetation and landscape conditions. This was basically to present a background on constraints and opportunities, which frame the potential of future management. It includes the spatial and quantitative depiction of ownership structure, fire management zones, identified wilderness and roadless areas.

The review of existing forest vegetation conditions took into account various key parameters used in standard forestry practices to describe and quantify a forest landscape. Particularly these are composition (cover types), structure (size classes and canopy cover/density classes), layering (vertical structure/ spatial arrangement) and habitat types (Pfister & Sweet, 2000).

Different classification variables were used for different alternative quantitative future scenarios. To facilitate comparison among the alternatives, several adaptations to a common classification were made.

Forest cover types

The occurrence of different combinations of tree species for a certain area leads to a definition of forest cover types. 'Dominance' is the degree, to which one or a few cover types dominate the landscape in proportional terms (Forman & Godron, 1986). In silvicultural terms, the

cover types are named after the tree species that has the most basal area (cross sectional area of tree boles at breast height), and at least 20 percent of total basal area (Eyre, 1980). If further tree species have at least 20 percent of the total basal area, subtypes can be identified. However, the SIMPPLLE classification defines cover types as follows (Chew et al, 2002):

If the average diameter is less than 5 inches, trees per acre are used.

If it is greater than or equal to 5 inches, basal area is used with the following percents.

- Single species - a single species must comprise 66 % basal area or more.
- Two species - two species must comprise 80% basal area or more.
- Three species - a combination of three species must make 66 % basal area or more.
- The sequence of species listed does not imply order of dominance.

SIMMPPLE cover types were cross-walked to aggregated cover types used by Losensky (1997) (Table 3) to facilitate the comparison of historic and current forest cover types. Since Losensky includes non-forest cover types as well, a conversion to the 291,192 forested acres of the study area is described in Table 16, with "effective" relating to 361,442 acres of naturally vegetated polygons (excluding the non-forest polygons XX1 – agriculture, XX4 – barren, and XX5 - water), and "normalized" to the adjusted percentage based on 291,192 forested acres.

Table 3. Relationship between SIMPPLLE and Losensky cover types within the Bitterroot Front Landscape

SIMPPLLE cover type	Losensky cover type
LP	LP Lodgepole pine
PP, PP-DF	PP Ponderosa pine
DF, DF-AF, DF-GF, DF-LP, DF-LP-AF	DF Douglas fir
AF, AL, AL-WB-AF, WB, WB-ES-AF	Sub Dominated by Lodgepole pine, whitebark pine, alpine larch, and mixtures of subalpine fir and spruce
L, L-DF, L-DF-AF, L-DF-GF, L-DF-LP, L-DF-PP, L-LP, L-PP, L-PP-LP	L-DF Larch-Douglas fir
ES, ES-AF	S-F Spruce-fir
C, CW, CW-MC, GF, QA	Other Fir-hemlock, Western redcedar, Western redcedar-Grand fir, Hardwood riparian
MESIC-SHRUBS, XERIC-SHRUBS, NATIVE-FORBS, UPLAND-GRASSES	NF Wheatgrass-Fescue, forbs, shrubs,

Stand structure

Stand structure types give insight into the successional stage and dimensional characteristics of a stand and provide background for possible susceptibility to damage agents (e.g. budworm, bark beetles, fire) (Pfister et al., 1999). Further, growth conditions and thus needs of management activities can be recognized.

The three components of stand structure types are (Classification follows the SIMPPLLE categories (Chew et al, 2002)):

Density types (tree canopy cover)

Non-forest (1) 0-14%),

Open (2) 15-39%,

Moderate (3) 40-69%,

Close (4) 70-100%.

Size types (diameter based)

Seedling/Sapling (SS) < 5",

Pole (P) 5-8.9" diameter breast height (dbh),

Medium (M) 9-14.9" dbh,

Large (L) 15-20.9" dbh ,

Very large (VL) ≥21" dbh.

(Note: The description of the size types is limited to the physical characteristic of bole diameter of the overstory canopy. The term "old-growth" or "old-forest" for very large trees is avoided on purpose to circumvent confusion with more complex ecological connotations that cannot be assumed solely on the basis of size class.)

Layer types (tree canopy layers) (x = size class)

'x' = single story,

xTS = two vertical stories with the largest being 'x' size,

'xMU' = three or more (multiple) vertical stories with the largest being 'x' size (Chew et al., 2002)

Structure types – Density x Layering x Size

The combination of the three variables density, size and layering into a single classification results in the definition of a particular structure type for each stand (Pfister et al., 1999). For the purpose of defining desired future condition scenarios the size/layer classes are aggregated into simple size classes.

A summary represents the existing conditions as the quantitative and qualitative starting point for the simulation efforts.

SIMPPLLE size classes were cross-walked to the classification used by Losensky (1997) (Table 4), which is based on age structure. A succession-treatment pathway model developed for

Table 4. Crosswalk between SIMPPLLE and Losensky (modified) size class definitions

SIMPPLLE size classes	LEF model [years][1]	Losensky size classes
non-stocked		non-stocked
Seedl./Sapl. (<5")	0 - 30	Seedl./Sapl. (1-40 yrs.)
Pole (5"-9")	31 - 60	Pole (41-100 yrs.)
Medium (9"-15")	61 - 90	
Large (15"-21")	91 - 120	Mature (101 yrs. - OS)
Very Large (>21")	> 120	Old stands (OS+)

[1]*Pfister, personal communication*

Lubrecht Experimental Forest by Pfister (personal communication, 2000) served as a guideline. The most obvious effect is the aggregation of the SIMPPLLE size classes "Pole" and "Medium" into Losensky's "Pole" class. The according resultant permits a comparison between historic and existing size classes (in Losensky's classification). For the reverse cross-walk, the amount of Losensky's "Pole" size class will later be divided proportionately in "Pole" and "Medium" size classes to match the SIMPPLLE size classes and to define the appropriate proportion of size classes on the Bitterroot Front landscape.

A combination of process-dominated methods and topographic criteria was used to develop quantitative target canopy layering estimates, particularly to address uneven-aged management considerations. The two basic categories applied in this analysis are single-story and multi-story canopy covers. Major factors for the establishment and maintenance of these types on the landscape are stand regeneration by stand-replacing disturbance events and regeneration without stand replacement, respectively.

In the following, fire group characteristics, which are based on habitat type groups, are used to assign the appropriate layering category. Stands with habitat type groups/ fire groups that traditionally experienced infrequent stand replacing fires are assigned single story canopies. Stands with frequent, low and moderate severity fire regimes that create perpetual seral

conditions are assigned to multi-story canopies. For management purposes these categories translate to even-aged and uneven-aged management, respectively (Table 5).

Table 5. Relationship between habitat type groups, fire groups, fire types, fire return intervals and management type

Fire group	HT Groups	Fire type	Return interval (yrs)	Stand habit	Management type
2	A2 (warm, dry PP)	low severity	5-25	Open	Uneven-aged
4	B1 (warm, dry DF)	low severity	5-25	Open-Moderate	Uneven-aged
6	B2, B3, C1 (moist DF)	mixed severity	40	Moderate-Dense	Uneven-aged
7	F1 (cool LP)	mixed severity	<100-500	Open	Even-aged
9	D2, D3, E2 (moist, lower subalpine)	high severity	>120	Dense	Even-aged
10	G1, G2 (cold, moist upper subalpine)	high severity	>200	Moderate-Dense	Even-aged
11	C2 (moist GF, C, WH)	high severity	100 - >200	Dense	Even-aged

Based on Fischer & Bradley 1987

To derive density estimates for the ancient forest landscape, stands were classified according to their stand habit (Fischer & Bradley, 1987) (Table 5).

Vegetation pathways

To simulate the changing landscape over time, logical vegetation pathways describe the sequence of vegetative states with succession and disturbance processes acting as agents for change from one state to another (Stalling, 1998). In the SIMPPLLE model each state is described as a combination of dominant species, size class, structure, and density within a habitat type group (Chew et al., 2002). The pathway files are a collection of all possible vegetation states and contain the applicable processes for each state as well as the resulting states. This includes habitat type effects, density effects, density changes, as well as seral and tolerant tree species response to these parameters.

Data sources

The main database is a revised "wbitterroot" SIMPPLLE dataset "face062102", updated to "face102303" to represent the 2000 and 2003 fires, as a combination of TSMRS data (Timber Stand Management Record System) and SILC1 data (Satellite Image Landcover Classification, version 1), 1990-2002, obtained from the USDA Forest Service, Rocky Mountain Research Station, Forestry Sciences Lab, RWU 4151 Forest Ecology and Management. The revised database delineates large non-forest and non-stocked polygons with more detail. The data relates directly to the stand delineation boundaries and contains information for every stand forest-wide, regarding acres, habitat type group, species, size class, density, ownership, roads, disturbance lock-in, and processes. No field verification for data base consistency was conducted. Instead of the default SIMPPLLE files, modified Bitterroot specific pathway files were obtained from Jimmie Chew (USDA Forest Service, Forest Sciences Lab, Missoula) to adjust for locally specific landscape conditions (Appendix A). Further modifications were made by Chew for disturbance process, i.e. Insect/ Disease and Fire related modules to adjust for mortality due to light Western spruce budworm infestation and very-large tree mortality (Appendix A).

An analysis of simulation output revealed several inconsistencies in the BNF-Bitterroot Front database. According to a personal communication with Jimmie Chew (USDA Forest Service, Forest Sciences Lab, Missoula) and Robert Pfister (Research professor (emerit.), forest ecology, The University of Montana), appropriate re-assignment and a following rerun of the model would have no significant effect on overall simulation results. A sensitivity analysis to quantify possible cumulative effects was not conducted. Hence, the problems are only listed here as reference for future database consolidation and the reassigned values used in the analysis.

SIMPPLLE habitat type group (HTG) F2: 25,711 acres of the study area are labeled as HTG F2. According to a personal communication with Robert Pfister (2004) this assignment can be questioned because none of the habitat types (h.t's) listed in HTG F2 were sampled on the

Bitterroot National Forest and reported in Appendix A (p.150-151) in Pfister et al. (1977). Most h.t's in HTG F2 are east side types according to the written type descriptions. Further a review of the h.t's of the 226 FIA plots for the Bitterroot National Forest indicated none to be in HTG F2.

To reassign 25,711 acres to appropriate HTGs the Cover Type data for the HTG F2 stands was examined and compared with the cover types in the other subalpine HTGs. The Cover Types in HTG F2 are AL-WB-AF (Alpine larch – Whitebark pine – Subalpine fir) (4,026 acres), NS (non-stocked) (18acres), and WB-ES-AF (Whitebark pine – Engelman spruce – Subalpine fir) (21,667 acres). Since these Cover Types would not be expected in HTG F1 (Pfister, personal communication) the database was revised as follows (Table 6): The AL-WB-AF Cover Type (4,026 acres) are reassigned to HTG G2 because most of the AL stands are in HTG G2 and because the LALY-ABLA (*Larix lyallii, Abies lasiocarpa*) h.t's are in HTG G2. AL is only found in the ABLA/LUHI-MEFE (*Abies lasiocarpa, Luzula hitchcockii, Menziesia ferruginea*) h.t. (G1) and in the LALY-ABLA h.t. (G2) according to Appendix B (p. 152) (Pfister et al., 1977). Further WB is not found in ABLA/LUHI-MEFE so they should not be put in HTG G1. Accordingly the WB-ES-AF Cover Type (21,667 acres) is put in HTG G1 because it includes the h.t's where WB is expected to be a major component according to Appendix B. The 18 acres of NS are also assigned HTG G1.

Table 6: SIMPPLLE habitat type group F2 re-assignment for the Bitterroot Front Landscape

Cover type	Acres	Reassigned HTG	Old HTG
WB-ES-AF	21,667	G1	F2
AL-WB-AF	4,026	G2	F2
NS	18	G2	F2
Total	25,711		

SIMPPLLE habitat type group XX5 – Water: Various polygons in the designated wilderness part of the study area are labeled HTG XX5 "Water", but several of them occur along ridge lines and are not consistent with a BNF data set for lakes. This problem was left unaccounted.

Forest ownership: The Ownership map (Map 3) (KIND in the original data set) shows extensive land area in the valley under National Forest ownership, while a similar map in an unpublished Bitterroot Landscape Assessment Draft (Bitterroot National Forest, 1999) shows the entire valley as Private land with only small islands in State ownership. This problem was left unaccounted.

Forest kind: The administrative unit map (Map 5) (OWNERSHIP in the original data set) shows large areas in the wilderness part and several polygons in the Forest Service managed area as OTHER rather than the appropriate NF-Wilderness and NF-Other. This problem was left unaccounted.

The latter two problems distort the representation of administrative boundaries and probably affect the present simulation results since the assumed acreage distribution is embedded in the fire suppression logic in the model (Chew et al., 2002), where land ownership and legal designation of forest land form constraints for management considerations.

Models (SIMPPLLE)

SIMPPLLE (v2.2), acronym for SIMulating Patterns and Processes at Landscape scaLEs, is a spatially explicit, stochastic knowledge-based computer program that simulates changes in vegetation over time under the influence of disturbance processes with and without management treatments (Chew et al., 2002). The model provides simulation capabilities to identify the acreage distribution over time of disturbance processes. It is used to provide estimates of future vegetation conditions for the no-treatment alternatives, based on a set of 30 simulations over 12 10-year cycles, and establishing the averages as quantitative benchmarks. Known conditions of particular stands (insect and disease infestations) were included and considered in the simulation. From the wide array of simulation capabilities of SIMPPLLE, this study uses only the simulation of "future vegetation changes caused by disturbance processes" (Chew et al., 2002) and natural succession.

Map 5. Spatial distribution of administrative units within the Bitterroot Front Landscape

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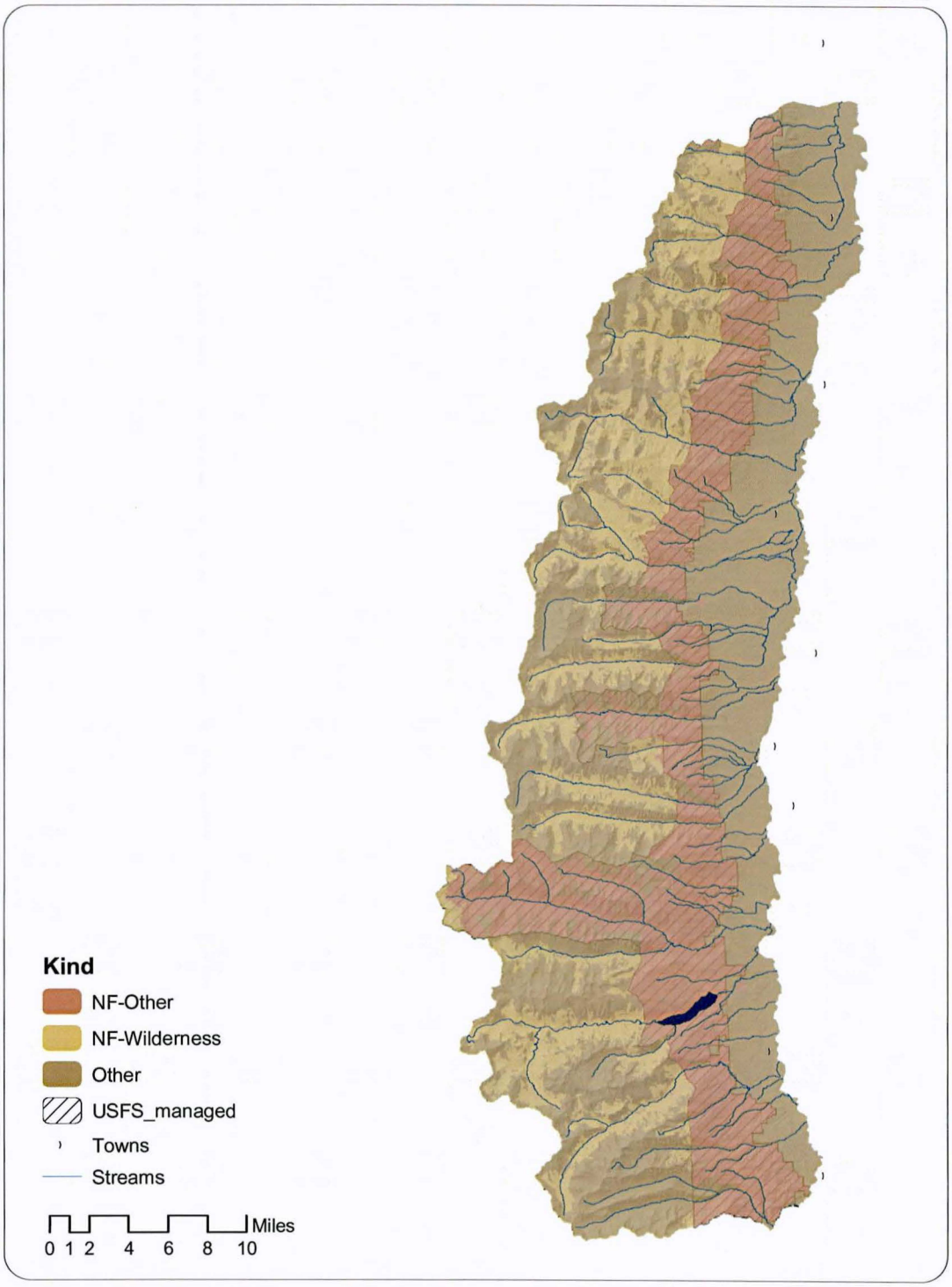

Flexibility in displaying complex data: Cross-tabulation in EXCEL

Graphical and numerical presentation of existing conditions and modeling results were presented by plotting acres by types, in some instances vs. time. To prepare the large amount of data for this complex task, cross-tabulations are used. The use of Pivot Tables in Microsoft's EXCEL allows the display of data, both, discrete and continuous, contained in a column of an EXCEL list (database) by means of subtotals (or other calculations) that are defined by another column in the same list. Other calculations might be averages, counts, percentages, standard deviations, minimum, maximum, variance, and so on.

Four key reasons for organizing data in a cross tabulation are:

- To summarize multivariate data contained in a long list into a condensed format;
- To identify relationships and patterns within the data that are otherwise hard to identify and analyze because of a high amount of detail and complexity;
- To organize and restructure the data into a format that is easy to chart;
- To simplify the arrangement of different variable combinations by editing the table without having to re-create it.

To construct the cross tabulation, two elements in the raw data need to be identified: a data field with the variable to be summarized and a row and/or column field as the "keys" that will "control" the data summary. A third dimension can be established by assigning a variable to a page. The three-step Pivot Table wizard in EXCEL facilitates the selection of the data location/ data base, the list range of the source data to be analyzed, and the destination location of the finished table. To edit the arrangement of the variables after the creation of the table, row fields can be changed to column fields, as well as a column fields into a row fields through "drag and drop" operations. The definition of subsidiary or inner row or column fields allows more than two variables in the list to be used as row or column fields by adding variables from the original list to the row/column fields. The data field is first summarized by the value of the outer row/column

field. Within that first level summary, the data field is further summarized by the corresponding values of the inner row/column field. This multi-level presentation provides a more detailed and complex but still compact display. If the data displayed can't be sorted as desired, individual items in the table can be selected and moved.

Design of desired future vegetation conditions

The definition of desired future vegetation conditions is based on various approaches to landscape perspectives and management applications, and has evolved as a tool for setting planning goals in natural resource and forest planning (Nygren, 1999). From an infinite number of possible vegetation states a forest landscape might display over time, a subset of four are selected to embrace a range of ecological, social, and economical objectives in regard to potential forest conditions as well as desired commodities, each of them addressing a noticeably different goal (Dewhurst & Kessler, 1999).

The quantitative scenario goals for all but the "no-action" alternatives are literature-based and guided by results from previous studies, whereas simulation results from the SIMPPLLE model provide the corresponding outcomes for the "no-action" null-model.

The ecological restoration alternative and the ecological diversity alternative are "area-controlled". Planning for sustainable timber harvest can be addressed by "area control" or "volume control". For this landscape assessment, an area control method will be used. "Area-controlled" refers to specified thresholds placed on forest areas in a certain structural state, while "volume-controlled" refers to an even level of timber volume harvested.

The no-action alternatives represent an average of multiple runs of the SIMPPLLE model (Chew et al., 2002) assuming no management action at all, as well as no management action but including traditional fire control, e.g. fire suppression and controlled burning.

The ecological restoration alternative tries to emulate forest conditions that most likely existed before Euro-american settlement in the area, disregarding the potential effects of climate

change on site conditions as well as vegetation composition and structure. It focuses on natural disturbance cycles and the typically created and maintained landscape patterns and features - mainly tree species composition as well as the forests density and size structure.

The ecological diversity alternative is based on habitat requirements of wildlife in general rather than on a single species focus. It draws from an approach by Haufler et al. (1996) who proposed a "coarse filter" approach to defining forest structure related to habitat needs. A functional linking of vegetation structure types and habitat characteristics for selected wildlife species is required, e.g. dense old forest as hiding and thermal cover compared to open young stands that provide forage. Since a certain set and amount of critical habitat characteristics are required to maintain wildlife populations, the desired future condition has to address this fact by defining adequate portions of forest in the desired structure types.

The sustainable timber production alternative is "area-controlled" to roughly achieve an even flow of timber harvest on the highest possible, but sustainable level. "Sustainable" is defined here narrowly and specific in the context of "a method of forest management that calls for an approximate balance between net growth and amount harvested" (Canadian Ministry of Forests, 2001b). Quantitative goals are compared to the Bitterroot Forest Plan (Bitterroot National Forest, 1987). Potential yield calculations are based on estimating site productivity by using habitat type groups (Pfister et al., 1977), and are complemented by standing timber volume estimates.

The design process to meet the desired future conditions as a whole requires decision making for every stand for each time period. Single stands are subject to silvicultural management activities or left to natural succession to move the landscape towards the desired future conditions.

Results

Existing conditions (EC) in Region 1 classification

The description of the existing conditions in a traditional way focuses on silviculture and forest planning and provides a direct stand-landscape linkage. The existing vegetation of the study area reflects the processes that changed the pattern of this landscape over time. Resulting landscape patches are more or less distinctly visible on aerial photos and are used to delineate polygons for analysis and management (Pfister, personal communication). The present Bitterroot Front inventory describes 18,533 polygons with four parameters needed for landscape analysis: composition (dominant cover types), structure (size class and canopy cover/ density class), layering (vertical structure/ spatial arrangement), and habitat type group.

Forest cover types

Thirty-five forest cover types identified for the assessment area are displayed in Table 7. For practical analytical purposes the numerous multi-species cover types were aggregated into higher level single-species types.

The subalpine fir cover type on 10% of the forested area is dominating the headwater drainages of Lost Horse Creek and occurs in small patches throughout the area above the dry bottom lands of the Bitterroot valley (Map 6). Alpine larch cover types (2.5%) are found along ridgelines and steep faces mostly in the northern third of the study area with scattered presence in the remaining part. Only four cedar stands are identified in the valley bottom along with cottonwood cover types (7%), which are found mostly in the northern part of the valley bottom along the Bitterroot River between Stevensville and Pinesdale and in few spots in high mountain stream bottoms. As the dominant cover type on more than 25% of the forested area, Douglas fir types dominate the valley bottoms along most of the mountain streams except the Lost Horse Creek headwaters (subalpine fir dominated) and the Trapper Creek valley in the south, which holds the largest contiguous occurrence of Quaking aspen (1%) in the study area except a few smaller patches in the Bass Creek, Kootenai Creek area in the north. Spruce (1.5%)

Table 7. Summary of SIMPPLLE cover types and associated acreages and percent of total within Bitterroot Front Landscape

Cover types used for SIMPPLLE	Acres	%	Agg. Cov. type	Acres	%
AF – Subalpine fir	30,035	10.2	AF	30,035	10.2
AL – Alpine larch	2,765	0.9	AL	6,791	2.3
AL-WB-AF – Alpine larch-Whitebark pine-Subalpine fir	4,026	1.4			
C – Cedar	47	0	C	47	0.0
CW – Cottonwood	2,958	1	CW	20,810	7.1
CW-MC – Cottonwood-Mixed conifer	17,852	6.1			
DF – Douglas fir	54,244	18.5	DF	74,972	25.6
DF-AF – Douglas fir-Subalpine fir	2,886	1			
DF-GF – Douglas fir-Grand fir	246	0.1			
DF-LP – Douglas fir-Lodgepole pine	1,731	0.6			
DF-LP-AF – Douglas fir-Lodgepole pine-Subalpine fir	15,865	5.4			
ES – Engelmann spruce	7	0	ES	4,039	1.4
ES-AF – Engelmann spruce-Subalpine fir	4,032	1.4			
GF – Grand fir	187	0.1	GF	187	0.1
L – Western larch	141	0	L	25,386	8.6
L-DF – Western larch	6,652	2.3			
L-DF-AF – Western larch-Douglas fir-Subalpine fir	14,193	4.8			
L-DF-GF – Western larch-Douglas fir-Grand fir	243	0.1			
L-DF-LP – Western larch-Douglas fir-Lodgepole pine	2,517	0.9			
L-DF-PP – Western larch-Douglas fir-Ponderosa pine	737	0.3			
L-LP – Western larch-Lodgepole pine	127	0			
L-PP – Western larch-Ponderosa pine	699	0.2			
L-PP-LP – Western larch-Ponderosa pine-Lodgepole pine	77	0			
LP – Lodgepole pine	20,287	6.9	LP	20,287	6.9
PP – Ponderosa pine	26,563	9.1	PP	65,978	22.5
PP-DF – Ponderosa pine-Douglas fir	39,415	13.4			
QA – Quaking aspen	2,543	0.9	QA	3,524	1.2
QA-MC – Quaking aspen-Mixed conifer	981	0.3			
WB – Whitebark pine	8,732	3	WB	30,399	10.4
WB-ES-AF – Whitebark pine-Engelmann spruce-Subalpine fir	21,667	7.4			
NS – non stocked	6,047	2.1	NS	10,674	3.7
MESIC-SHRUBS	1,573	0.5			
XERIC-SHRUBS	1,616	0.6			
NATIVE-FORBS	92	0			
UPLAND-GRASSES	1,346	0.5			

Map 6. Spatial distribution of cover types (aggregated to single species types) within the Bitterroot Front Landscape

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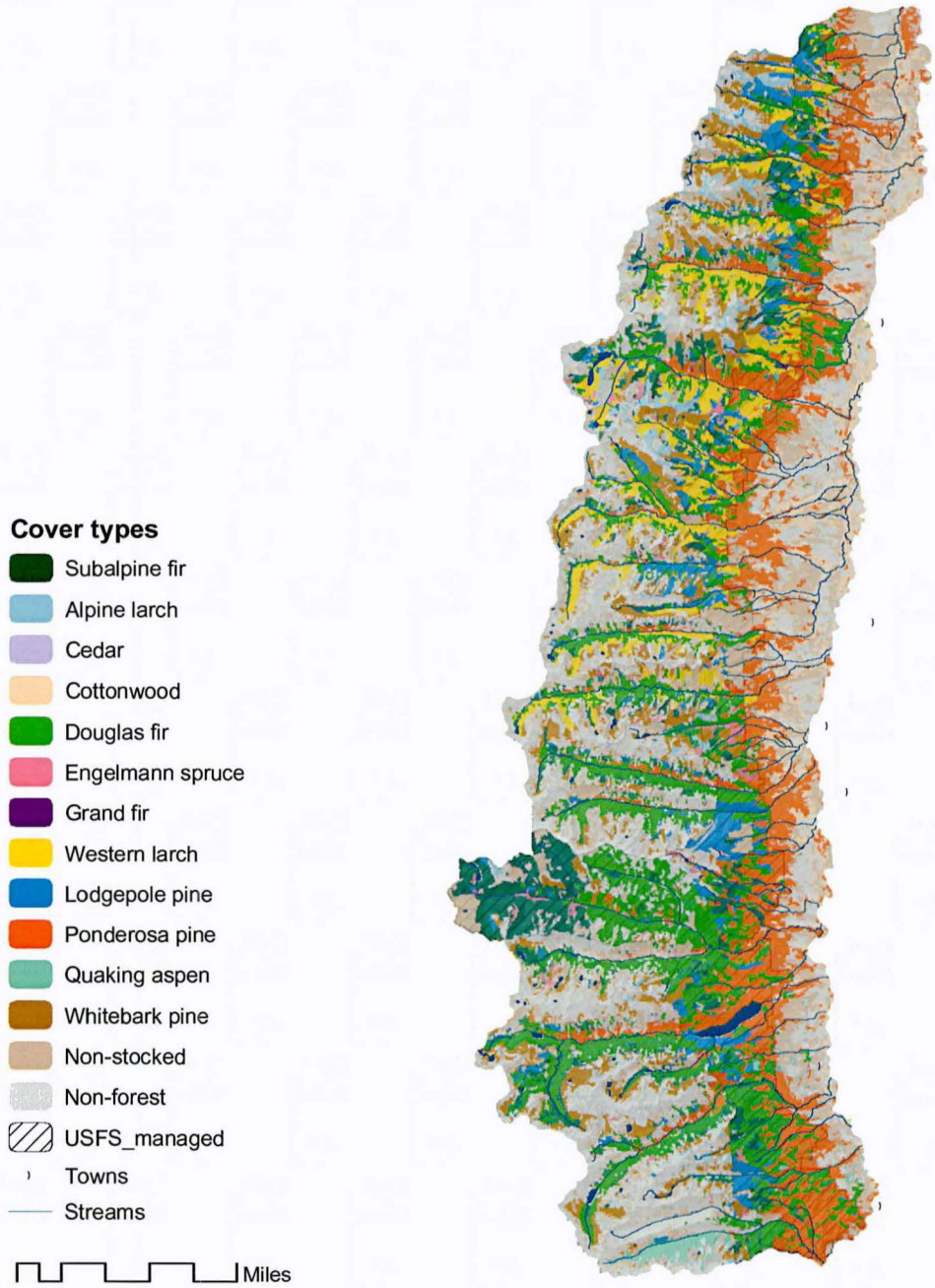

and Grand fir cover types have only a small amount of scattered presence. Western larch cover types (8.5%), which are dominating many north and north-east facing slopes in the northern half of the study area have their distinct southwestern limit in the area around Hamilton (Map 6). Lodgepole pine cover types (7%) are scattered throughout the area and are commonly found on south and east facing slopes. Pure Ponderosa pine cover types (22.5%) form the lower timber line and dominate the Bitterroot River valley in a mélange with agricultural land and cottonwood stands, while many mixed stands with Douglas fir line the south facing slopes along mountain creeks and the east facing foothills towards the Bitterroot valley. Whitebark pine cover types (10.5%) occur in numerous small patches forming the upper timber line. About 3.5% of the forested area is currently non-stocked.

Stand structure

The acres and percent of total forested area of the three forest structure components are displayed in Table 8 (density), and Table 9 (size and layering). Classification follows the SIMPPLLE categories (Chew et al, 2002).

Density types

The density type is a measure for the total percent cover of the tree canopy and is a visual estimate. Major parts of the assessment area (71%) have an open (15 - 39%) canopy and 20% of the forested land moderate (40 - 69%) canopy. A small amount of the area (5%) has dense or closed (70 -100%) canopy and another small part has canopy formations (0 - 14%), that are not considered as forested (Chew et al., 2002) of almost 4% (Table 8). These are generally stockable but currently have no significant stocking that would qualify for a density value (Map 7).

Table 8. Acreage summary by four density classes (canopy cover) within the Bitterroot Front Landscape

Density	Non-forest (0-14%)	Open (15-39%)	Moderate (40-69%)	Dense (70-100%)
Acres	10,674	208,916	57,956	15,583
%	3.6	71.3	19.8	5.3

Table 9. Summary of aggregated and un-aggregated acreages by SIMPPLLE size class and layer class within the Bitterroot Front Landscape

Size/Layer	Acres	%	Acres	%
	Un-aggregated		Aggregated	
SS – <5"dbh	29,561	10.1	29,561	10.1
POLE – 5"-8.9"dbh	75,630	25.8	79,953	27.3
PTS	-	-		
PMU	4,323	1.5		
MEDIUM – 9"-14.9"dbh	33,364	11.4	33,406	11.4
MTS	-	-		
MMU	42	0		
LARGE – 15"-20.9"dbh	43,894	15	90,348	30.8
LTS	-	-		
LMU	46,454	15.8		
VERY-LARGE – ≥21"dbh	820	0.3	49,187	16.8
VLTS	16,257	5.5		
VLMU	32,110	11		
NS–non-stocked	6,047	2.1	10,674	3.6
CLOSED-LOW-SHRUB	1,573	0.5		
OPEN-LOW-SHRUB	1,616	0.6		
CLOSED-HERB	1,346	0.5		
OPEN-HERB	92	0		

xTS = two vertical stories with the largest being x size

xMU = three or more (multiple) vertical stories with the largest being x size (Chew et al., 2002)

The majority of the moderate and dense canopy cover is on the land managed by the US Forest Service (Map 7, hatched area). Most stands in the wilderness area are classified as open canopies or are not considered forested, but a number of stands in the wilderness part of the Trapper Creek area in the south and the Big Creek area in the north exhibit moderate and dense conditions.

Map 7. Spatial distribution of density classes (tree canopy cover) within the Bitterroot Front Landscape

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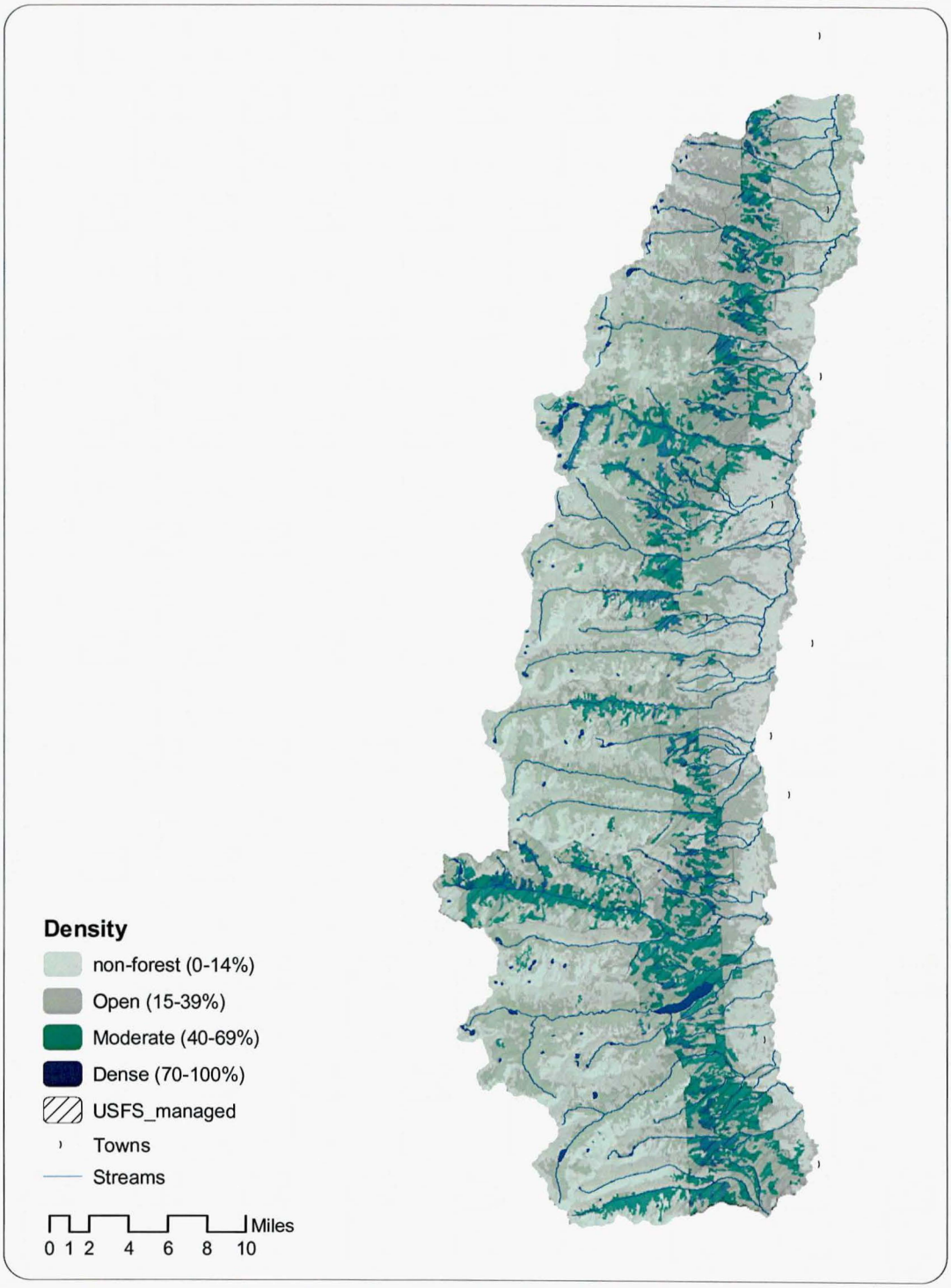

Size types

The size type describes the successional stage of a stand. Almost 31% of the forested area is recorded as large sized class (9"-14.9" diameter at breast height). Some 27% are classified as pole sized class (5"-8.9" dbh). Another 17% were classified as very large (>21" dbh) and about 11% are identified as medium size class (15"-20.9" dbh). An additional 10% of the stands are in the seedling/sapling stage. About 4% are currently in a non-stocked stage. No distinct spatial pattern can be described for the occurrence of the different size classes other than the very large class, which is found mostly in the lower parts of Big Creek, Lost Horse Creek, Trapper Creek and the headwaters of Lost Horse Creek (Map 8).

Layer types

The layer type describes the vertical structure of the forest canopy, which is generally related to the distribution of size classes within a stand. Vertical structure is created by continuing re-establishment of shade tolerant species under a forest canopy and by resumption of regeneration following natural and human disturbances that remove part of the original canopy (e.g. mixed severity fires and partial cutting). Vertical structure is an important habitat component for many wildlife species, susceptibility to dwarf mistletoe, spruce budworm (spread mechanisms), and to crown fires (fuel ladder).

Structure types – Density x Layering x Size

Most of the forested stand area is in open single story pole size (17.8%), open multi-story large (14.2%), and open single story large (12.7%) structure types (Table 10). Most of these occur in the wilderness part and the private lands of the study area, while the US Forest Service managed area displays a fine grained mosaic of most other structure types, which occur only in small amounts and spatially distributed, providing a high variance in forest structure (Map 9). Only parts of the wilderness area around Big Creek and Sweathouse Creek offer similar heterogeneity. For aggregated simple size classes see Table 11.

Map 8. Spatial distribution of size classes (aggregated) within the Bitterroot Front Landscape

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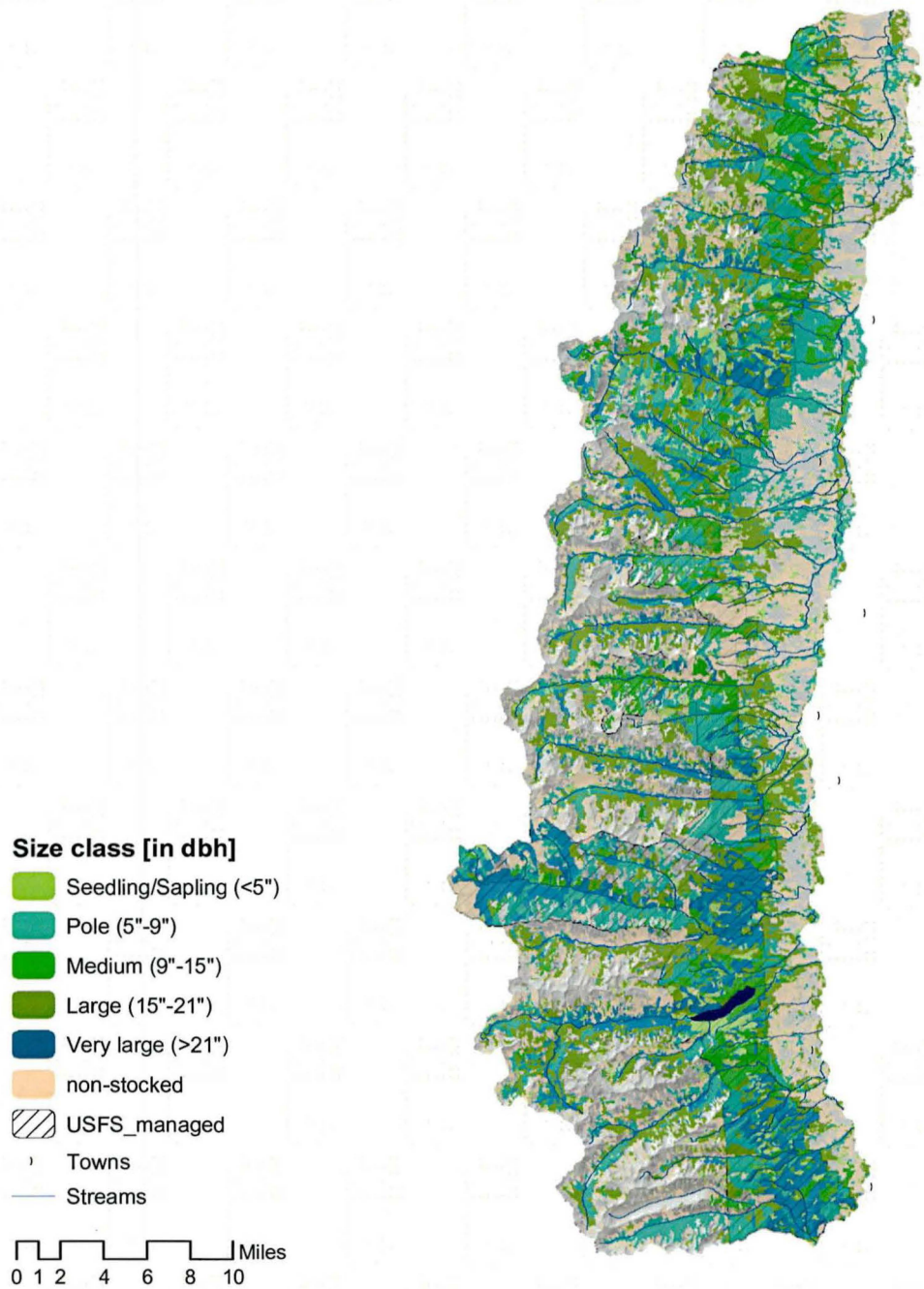

Table 10. Summary of structure types within Bitterroot Front Landscape

Size-Layer/Density	non-stocked (0-14%)	Open (15-39%)	Moderate (40-69%)	Closed (70-100%)	Total
SS	-	9.2%	0.6%	0.3%	10.1%
Pole	-	17.8%	5.7%	2.3%	25.8%
PTS	-	-	-	-	-
PMU	-	1.5%	0.0%	0.0%	1.5%
Medium	-	5.7%	4.8%	0.9%	11.4%
MTS	-	-	-	-	-
MMU	-	0.0%	0.0%	0.0%	0.0%
Large	-	12.7%	1.8%	0.5%	15.0%
LTS	-	-	-	-	-
LMU	-	14.2%	1.4%	0.2%	15.8%
Very-Large	-	0.3%	0.0%	0.0%	0.3%
VLTS	-	3.5%	2.0%	0.0%	5.5%
VLMU	-	6.2%	3.5%	1.2%	11.0%
Non-stocked	3.6%	-	-	-	2.1%
Total	3.6%	71.3%	19.8%	5.3%	100.0%

Table 11. Summary of aggregated structure types within Bitterroot Front Landscape

Size/Density	non-stocked (0-14%)	Open (15-39%)	Moderate (40-69%)	Close (70-100%)	Size Total
Non-stocked	3.6%	-	-	-	3.6%
Seedl./Sapl.	-	9.2%	0.6%	0.3%	10.1%
Pole	-	19.3%	5.7%	2.3%	27.3%
Medium	-	5.8%	4.8%	0.9%	11.4%
Large	-	27.0%	3.2%	0.6%	30.8%
Very Large	-	10.0%	5.6%	1.2%	16.8%
Density Total	3.6%	71.3%	19.8%	5.3%	100.0%

Cover type – Structure type matrix

A combination of cover types and structure types in a two-way table summarizes the different variables in a way that reveals valuable information in a meaningful format for analysis and management planning (Pfister et al. 1999) (Table 12). The table displays a high variance of cover type – structure type combinations. While most combinations cover less than 1%, the most prevalent types are open canopies (15-39%) of large Douglas fir-types (7.5%), large Ponderosa pine-types (7.1%), and large Whitebark pine-types (6.3%), followed by pole size Cottonwood-

Map 9. Spatial distribution of structure types within the Bitterroot Front Landscape

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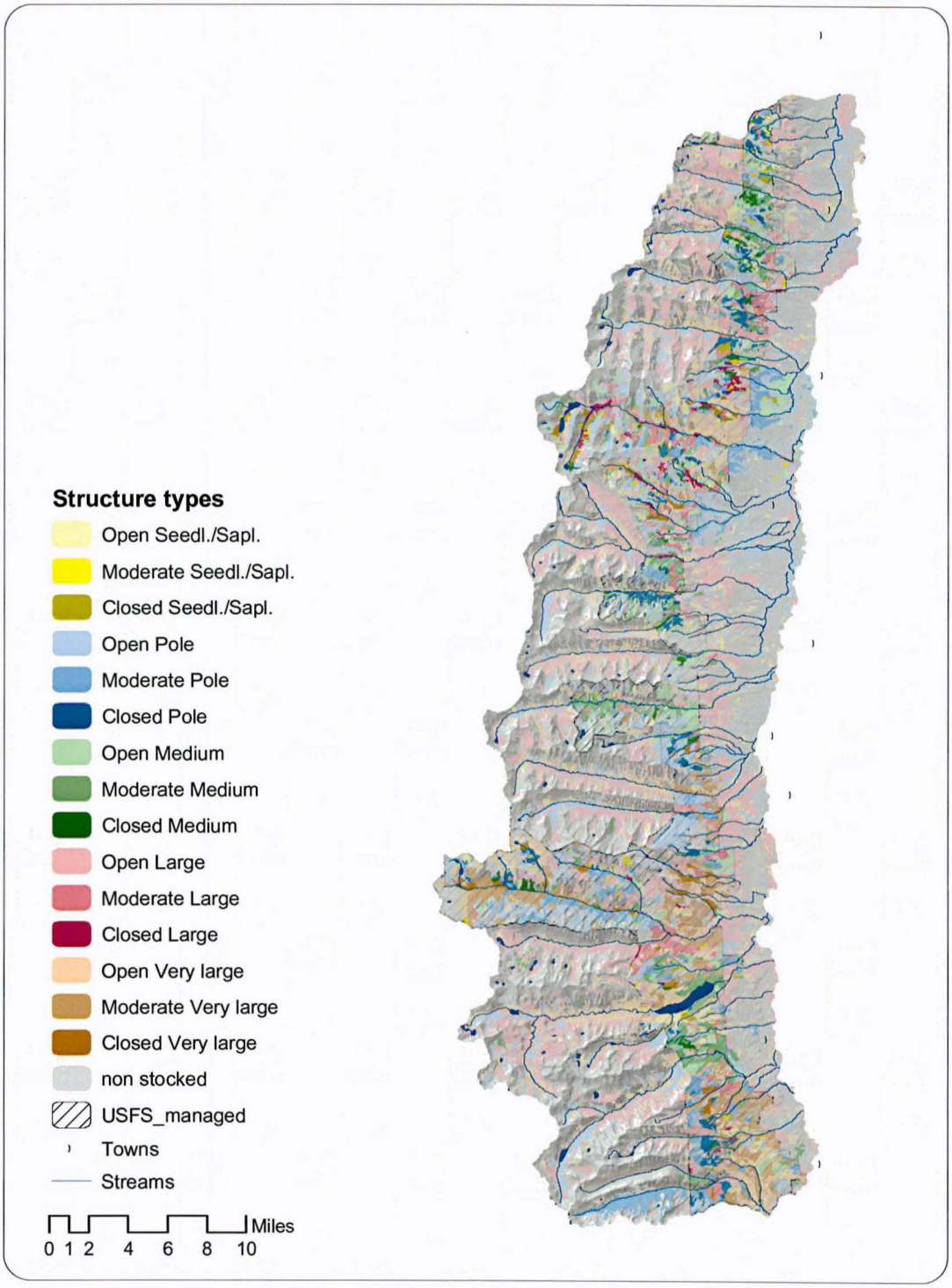

types (4.2%), pole size Douglas fir-types (4.0%), and very large Ponderosa pine-types (3.7%). The high complexity of the different combinations provides pronounced heterogeneity.

Table 12. Summary of cover type - structure type matrix elements (in % of forested area) within Bitterroot Front Landscape

Cover type / Structure type		AF	AL	C	CW	DF	ES	GF	L	LP	PP	QA	WB	NS	Total
1	ns	-	-	-	-	-	-	-	-	-	-	-	-	3.6	3.6
2	ss	0.6	0.7	-	1.0	1.0	0.1	-	0.6	1.0	2.9	0.2	1.3	-	9.2
	p	2.0	0.6	-	**4.2**	**4.0**	0.2	0.0	2.0	1.3	2.9	0.0	2.1	-	19.3
	m	0.5	0.1	0.0	0.1	1.5	0.3	0.0	0.4	0.5	1.5	0.0	0.7	-	5.8
	l	0.4	0.8	0.0	1.6	**7.5**	0.0	-	1.5	1.7	**7.1**	0.2	**6.3**	-	27.0
	vl	2.7	0.1	-	-	2.0	0.0	-	1.4	-	**3.7**	-	-	-	10.0
3	ss	0.1	-	0.0	0.0	0.3	0.0	0.0	0.1	0.0	0.1	0.0	-	-	0.6
	p	0.7	0.0	-	0.2	2.5	0.1	0.0	0.3	0.4	0.8	0.7	-	-	5.7
	m	0.2	-	-	-	2.4	0.2	-	0.7	0.3	0.9	-	-	-	4.8
	l	0.1	-	-	-	1.8	0.0	-	0.6	0.2	0.5	0.1	-	-	3.2
	vl	1.2	-	-	-	2.0	0.1	-	0.2	-	2.1	-	-	-	5.6
4	ss	0.1	-	-	-	0.0	0.0	-	0.0	0.1	-	0.0	-	-	0.3
	p	0.5	-	-	-	0.4	0.0	-	0.2	1.2	-	-	-	-	2.3
	m	0.5	-	-	-	0.1	0.1	-	0.1	0.2	-	-	-	-	0.9
	l	0.0	-	0.0	-	0.2	0.1	-	0.3	0.0	-	-	-	-	0.6
	vl	0.6	-	-	-	0.0	0.1	0.0	0.4	-	-	-	-	-	1.2
Total		10.2	2.3	0.0	7.1	25.6	1.4	0.1	8.7	6.9	22.5	1.2	10.4	3.6	100.0

Values: 0.0 = <0.05%, - = 0%
Density: 1 = 0-14%,2 = 15-39%, 3 = 40-69%, 4 = 70-100%
Size: ns = non-stocked, ss = Seedl./Sapl., p = Pole, m = Medium, l = Large, vl = Very large

Region 1 provided timber volume estimates for the Bitterroot National Forest area (Lundberg, personal communication 2004). Following the structure type - cover type matrix, the volumes were averaged according to single species cover types and the aggregated structure types to estimate the timber volume for the study area (Table 13).

Table 13. Summary of timber volume estimates for structure type - cover type matrix elements in hundreds of cu.ft./ac) within Bitterroot Front Landscape

Cover type / Structure type		AF	AL	C	CW	DF	ES	GF	L	LP	PP	QA	WB	NS	Total
1	ns	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	ss	4.3	2.5	4.3	3.6	4.0	4.4	2.4	4.0	4.7	4.4	3.2	7.1	-	4.0
	p	9.5	6.3	9.6	9.1	8.9	9.8	4.9	8.6	10.5	8.7	8.0	9.5	-	8.7
	m	14.0	9.0	14.0	14.8	12.8	14.2	8.0	12.6	15.0	13.7	11.6	13.2	-	12.9
	l	17.9	10.7	17.8	18.9	16.7	17.9	10.7	16.3	18.7	17.9	12.1	19.2	-	16.6
	vl	20.7	21.3	22.3	n/a	22.4	20.0	n/a	20.6	n/a	23.8	n/a	n/a	-	21.6
3	ss	5.7	3.1	6.4	5.0	6.0	5.4	3.6	6.0	5.5	6.1	4.8	10.4	-	5.7
	p	12.6	7.7	14.4	12.5	13.3	12.2	7.8	12.7	12.5	11.9	11.9	15.7	-	12.5
	m	18.3	11.6	20.5	22.2	19.0	17.4	12.0	18.6	17.8	18.6	17.2	20.9	-	18.4
	l	24.8	12.7	26.1	27.7	25.0	21.9	16.0	24.3	22.7	24.0	18.0	27.3	-	23.7
	vl	28.6	23.1	36.5	n/a	35.0	29.3	n/a	29.5	n/a	29.2	n/a	n/a	-	30.6
4	ss	7.2	n/a	7.5	6.1	7.4	6.5	4.2	6.9	6.9	7.0	5.6	n/a	-	6.7
	p	16.0	n/a	17.5	15.6	16.7	14.9	9.1	13.1	17.3	13.0	14.9	n/a	-	14.4
	m	23.2	n/a	25.7	28.0	23.8	21.7	15.0	23.3	24.7	23.3	21.5	n/a	-	23.3
	l	32.8	n/a	32.6	35.0	31.4	27.4	20.0	30.4	32.1	30.0	22.5	n/a	-	30.0
	vl	37.9	n/a	42.9	n/a	41.9	35.2	18.8	22.5	n/a	22.2	n/a	n/a	-	28.7
Total		18.2	10.8	19.9	16.5	19.0	17.2	10.2	16.6	15.7	16.9	12.6	15.4	-	17.2

Density: 1 = 0-14%,2 = 15-39%, 3 = 40-69%, 4 = 70-100%
Size: ns = non-stocked, ss = Seedl./Sapl., p = Pole, m = Medium, l = Large, vl = Very large

Habitat types and habitat type groups

Habitat types according to Pfister et al. (1977) provide a site classification as a basis for evaluating potential multi-resource productivity (Pfister et al. 1999) of the assessment area. Several studies exist to aggregate habitat types to habitat type groups based on "overall ecological similarities" (Pfister et al., 1999). Table 14 lists the habitat types groups found on the entire study area (467,481 acres) as defined in SIMPPLLE (Chew et al., 2002). For a display of the spatial distribution of the different habitat type groups for the Bitterroot Front landscape see Map 10.

Map 10. Spatial distribution of habitat type groups within the Bitterroot Front Landscape

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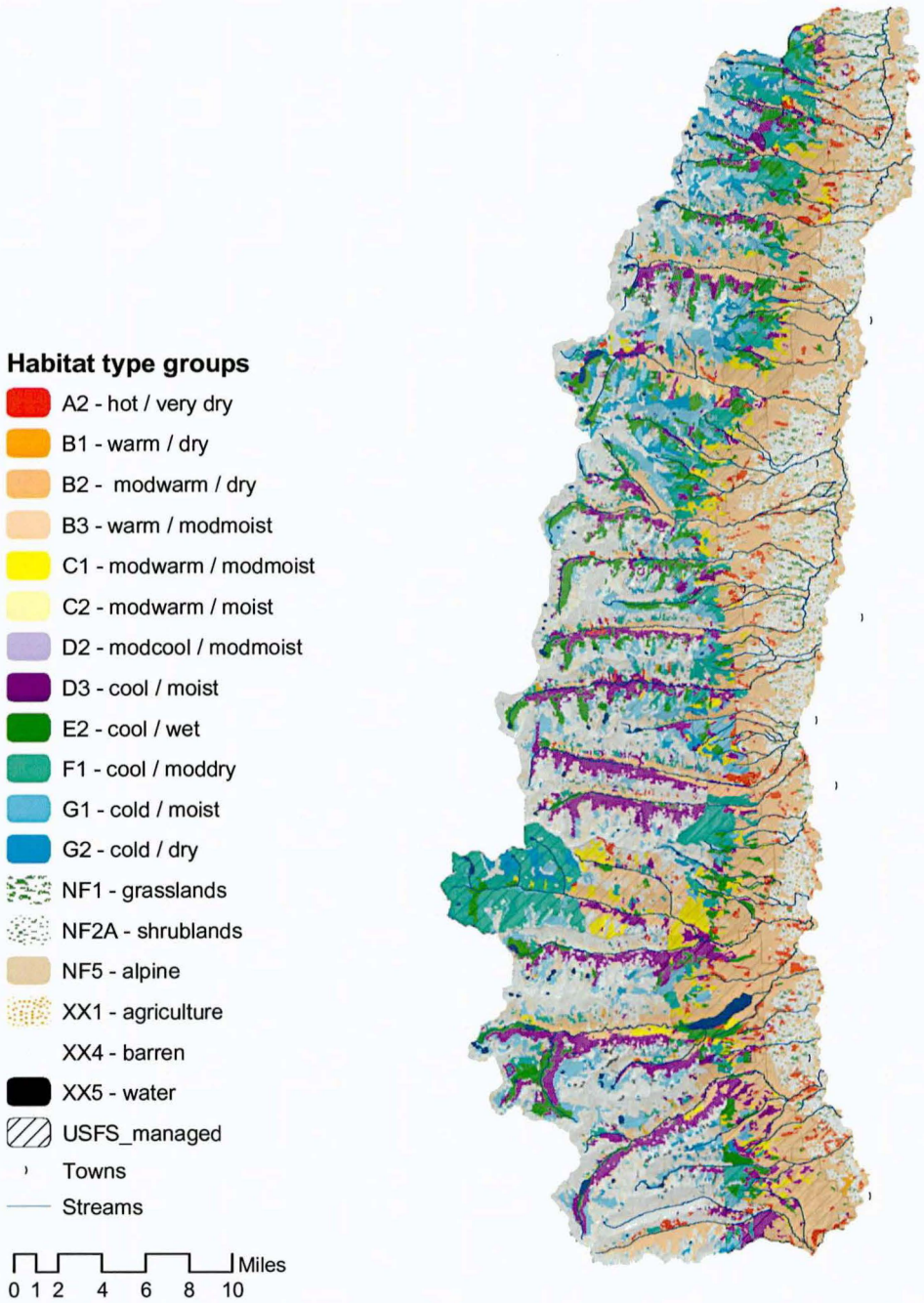

Table 14: Acreage summary of SIMPPLLE habitat type groups within Bitterroot Front Landscape

Habitat type groups	Acres	Total area %	Forested area %	Fire groups1
A2 – warm and very dry	9,616	2.1	3.3	2
B1 – warm & dry	939	0.2	0.3	4
B2 – moderate warm & dry	116,388	24.9	39.6	6
B3 – warm & mod. moist	277	0.1	0.2	6
C1 – mod. warm & mod. moist	11,946	2.6	4.1	6
C2 – mod. warm & moist	1,019	0.2	0.3	11
D2 – mod. cool & mod. moist	7	0.0	0.0	9
D3 – cool & moist	38,914	8.3	13.2	9
E2 – cool & wet	29,965	6.4	10.2	9
F1 – cool & mod. dry	35,823	7.7	12.2	7
G1 – cold & moist	39,116	8.4	13.4	10
G2 – cold & dry	9,119	2.0	3.2	10
NF1 – grasslands	23,237	5.0		
NF2A – shrublands	20,372	4.4		
NF5 – alpine	24,684	5.3		
XX1 – agriculture	20,495	4.4		
XX4 – barren	82,339	17.6		
XX5 – water	3,225	0.7		

1) Fischer & Bradley (1987): 2=warm, dry, Ponderosa pine; 4=warm, dry Douglas-fir; 6=moist Douglas-fir; 7= cool, usually dominated by Lodgepole pine; 9= moist, lower subalpine; 10= cold, moist upper subalpine and timberline; 11= warm, moist Grand fir, Western redcedar, and western hemlock;

The most dominant habitat type group is B2 on 25% of the total area (40% forested area), indicating moderate dry & warm site conditions. Other groups with significant coverage are the cold & moist G1 (8.4% total, 13.4% forested), cool & moist D3 (8.3% total, 13.2% forested), cool & moderate dry F1 (7.7% total, 12.2% forested), and cool & wet E2 (6.4% total, 10.2% forested). A significant amount (17% total) is barren land (XX4) above the timber line.

Fischer & Bradley (1987) published a grouping of habitat types evaluating habitat type characteristics related to ecological dependence and general susceptibility to fire. The classification of fire groups in this study is derived from cross-referencing habitat types in SIMPPLLE habitat type groups with the habitat types in the appropriate fire groups (Map 11). Almost 45% of the forested area is assigned to fire group 6 (Figure 2). This group basically

includes the moist Douglas-fir habitat types, with studies showing mean fire free intervals between 16 and 42 years. Fire group 9 is found on about 25% of the area that is comprised of moist and wet habitat types with spruce and subalpine fir. Fire free intervals here are around 120 years. Fire group 10 (17%) contains the "high-elevation forests near and at the timberline" (Fischer & Bradley, 1987) with long fire free intervals of 200 years or more. Fire group 7 occurs with roughly 12% and is dominated by lodgepole pine on cool habitat types and has fire free intervals of 100 years and longer. Other fire groups have only minor presence: Fire group 2 (3%), fire group 4 (0.3%) on warm and dry sites with Ponderosa pine and Douglas fir, respectively, and fire group 11 (0.3%) located on warm and moist sites characteristic for Grand fir and Western red cedar. Thus, the forested area has about 50% each relatively short (<50yrs.) and long (>100yrs.) fire free intervals.

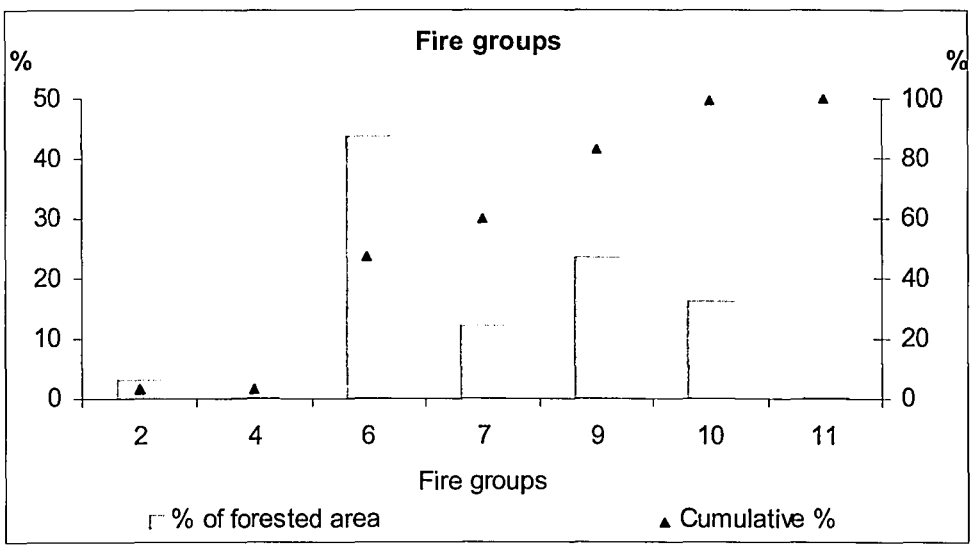

Figure 2. Frequency distribution of fire groups within Bitterroot Front Landscape

Pfister et al. (1977) estimated potential timber yield capability for habitat types to evaluate the annual increment potential for fully stocked natural stands (Table 15). The results show that 18% of the forested area has a high (85-120 cuft/ac/yr) timber productivity, 62% has a moderate (50-85 cuft/ac/yr) timber productivity, 17% has a low (20-50 cuft/ac/yr) timber productivity, and 3% has a very low (<20 cuft/ac/yr) timber productivity (Figure 3). Dry Ponderosa pine and Douglas-fir

Map 11. Spatial distribution of fire groups within the Bitterroot Front Landscape

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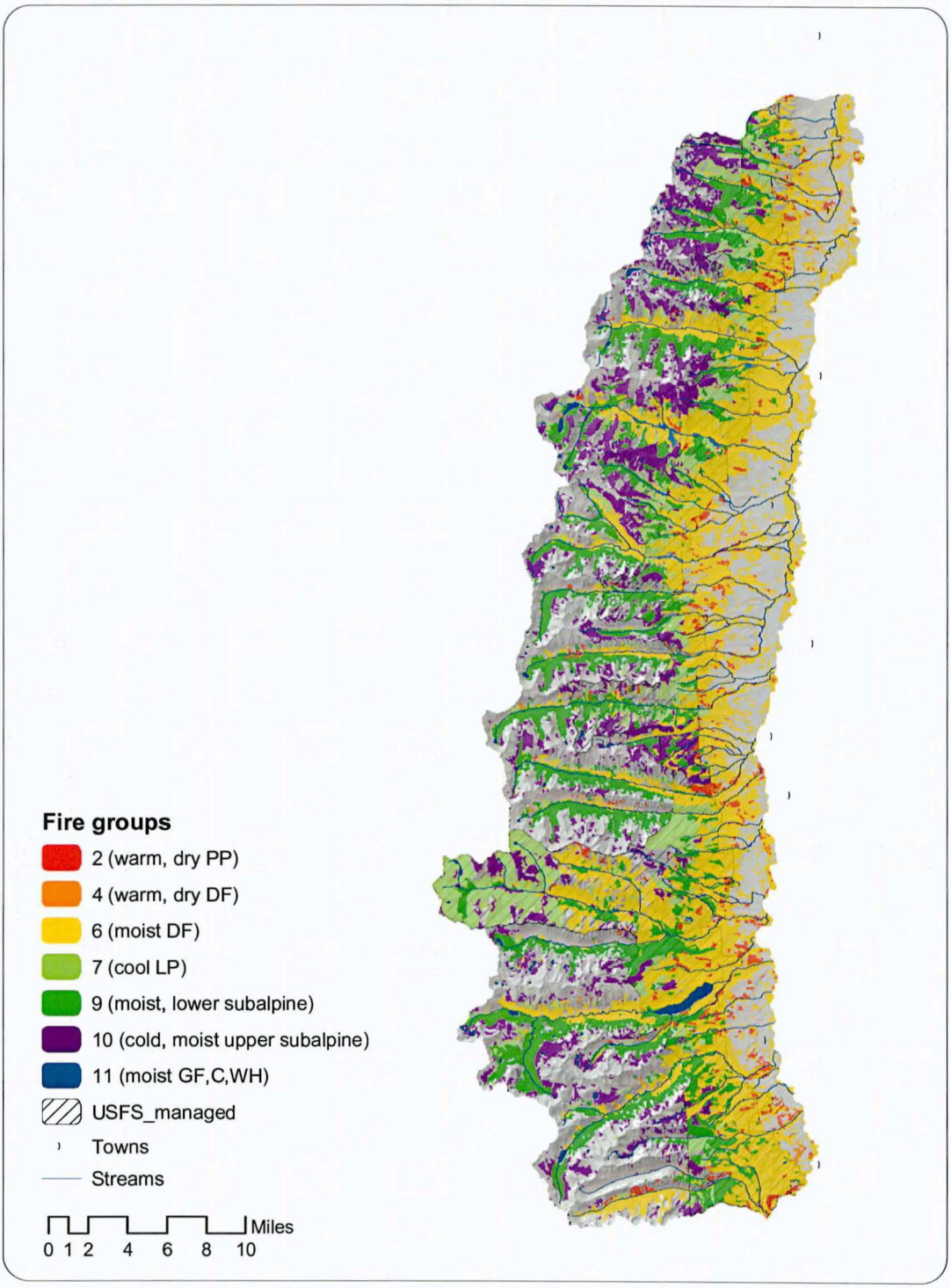

Table 15. Estimated timber productivity by habitat type groups and productivity groups within Bitterroot Front Landscape

Habitat type group	Acres	% forested area	MAI ft³/ac/yr [1)]	Productivity group	% forested area
C1	11,946	4.1	86-106	High	17.6
C2	1,019	0.3	108		
D3	38,914	13.2	81		
B1	939	0.3	59	Moderate	62.5
B2	116,388	39.6	52-70		
B3	277	0.2	52-74		
E2	29,965	10.2	63-83		
F1	35,823	12.2	50-65		
A2	9,616	3.3	17-40	Low	16.7
D2	7	0	32		
G1	39,116	13.4	33		
G2	9,119	3.2	<20	very Low	3.2

1) Pfister et al. (1977) Estimated mean annual increment (MAI) potential (cuft/ac/yr) for fully stocked natural stands (20-50=low; 50-85=moderate; 85-120=high)

sites in the valley bottom as well as high elevation sites along the timberline dominated by Whitebark pine and alpine larch have low and very low yield capability, while most of the moister sites along the faces of mountain creek drainages that are dominated by Douglas fir, Lodgepole pine and Western larch types show moderate and high yield capability.

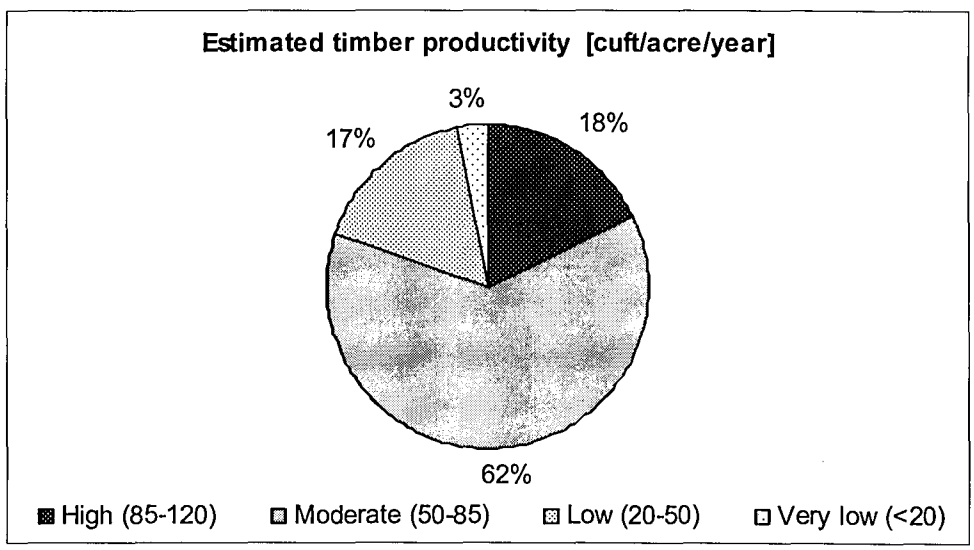

Figure 3. Graphical display of estimated timber productivity based on habitat type groups (Pfister et al., 1977) by four classes in percent within Bitterroot Front Landscape

Alternative Desired Future Conditions (DFC) as % of area by cover type, size class, density class

Desired future conditions (DFC's) are formulated as a means of achieving given management goals. A selection of alternative scenarios simulating landscape dynamics is used to display a range of future conditions, and allows addressing of appropriate management activities. Four alternatives are described as follows:

A. No-Action alternatives

   Without fire suppression

   With fire suppression

B. Ecological restoration alternative

C. Ecological diversity alternative

D. Sustainable timber production alternative

A. No-action alternatives

The assumption of these management alternatives is that: a) no stand management practices would be conducted and fires would be allowed to burn and b) only fire suppression activities would be applied during the twelve 10-year cycles of the 120-year projection period. The results are displayed in 30-year intervals from the exiting conditions in year 2000 to simulated conditions in 2120 for each alternative.

Compared to existing conditions (Figure 4 and Figure 5), both no-action scenarios double the large size class, and reduce to about one third the amount of forested landscape in the pole size class by the end of the simulation period. Within the first three decades most of the very large stands are replaced by younger age groups and recover gradually (Figure 4 and Figure 5). The similarity between the two scenarios ends here. Without fire suppression the landscape, in general, will provide a higher amount of non-stocked and regenerating young stands (seedling/sapling stage), mostly at the cost of old, mature stands (very large).

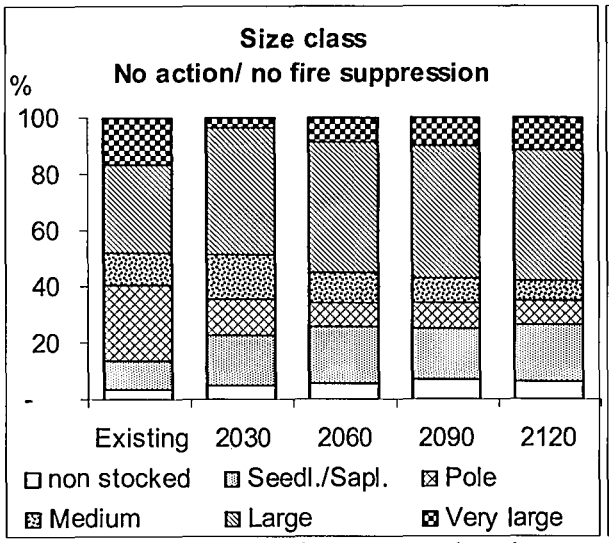

Figure 4. Stacked bar charts comparing size class distribution over 5 time periods for alternative scenario no action/ no fire suppression within Bitterroot Front Landscape

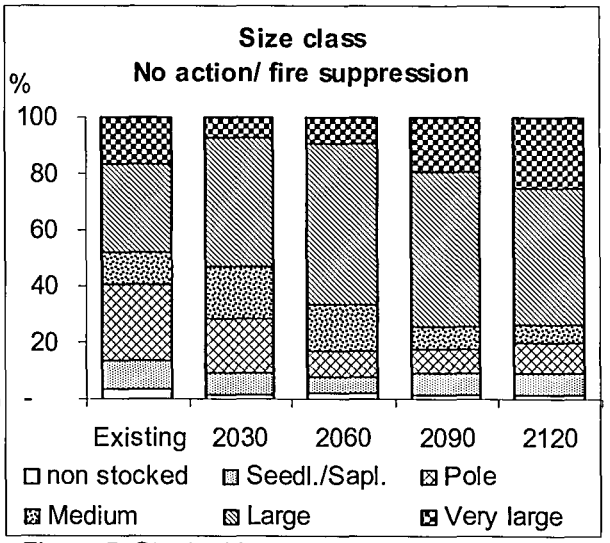

Figure 5. Stacked bar charts comparing size class distribution over 5 time periods for alternative scenario no action/ with fire suppression within Bitterroot Front Landscape

With fire suppression, about 80% of the forested landscape is in medium and larger size classes, non-stocked stands almost vanish completely and seedling/sapling stands and pole size stands cover only about 10% each (Figure 5).

Major differences in the trends of cover type are a steady increase in Douglas fir and significant decrease in Lodgepole pine, Western larch, Cottonwood as well as Quaking aspen if fires are suppressed and a decrease of Subalpine fir without fire suppression (Figure 6). In both scenarios Whitebark pine is almost eliminated, and Engelmann spruce thrives, while Ponderosa pine, Grand fir, and Alpine larch maintain the levels of the existing conditions (Figure 7).

Differences between the two no-action scenarios in regard to changes in canopy cover are marginal. Open (15-39%) canopies are significantly reduced and dense (70-100%) canopies increased sharply (Figure 8 and Figure 9). Fire suppression results in more dense and less open canopies, compared to no fire suppression. Moderate canopies (40-69%) are approximately equal with slightly higher acreage if fires are suppressed.

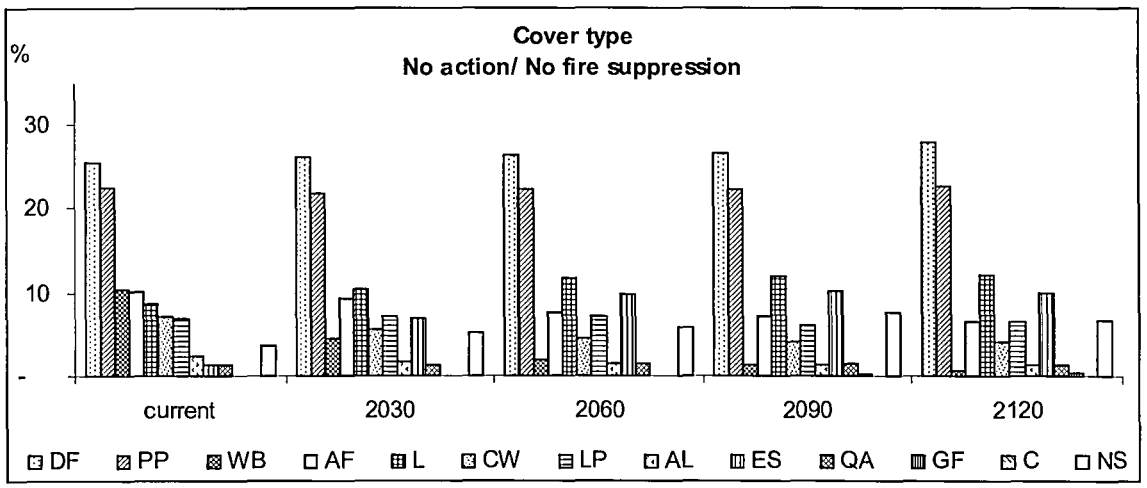

Figure 6. Grouped bar charts comparing cover type distribution over 5 time periods for scenario no action/ no fire suppression within Bitterroot Front Landscape

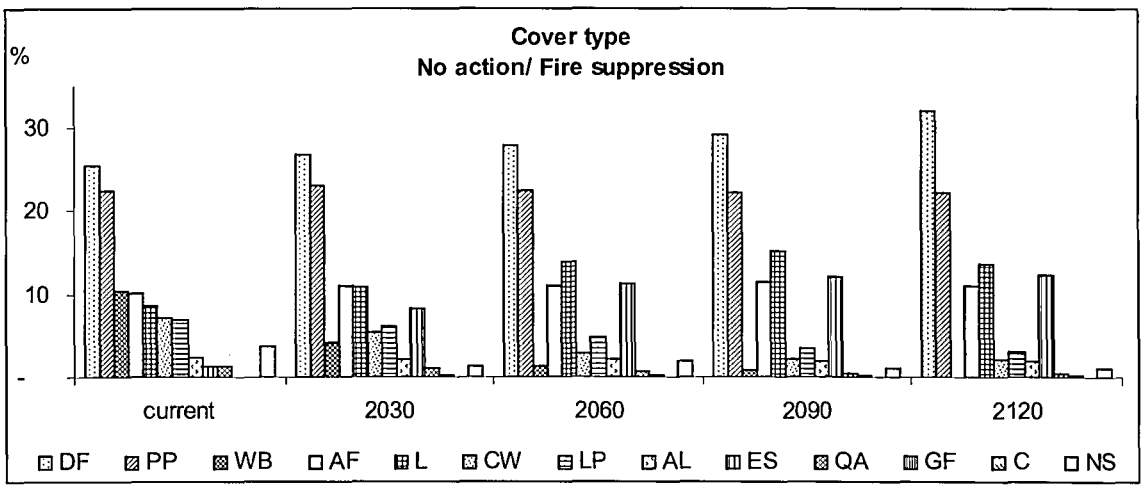

Figure 7. Grouped bar charts comparing cover type distribution over 5 time periods for scenario no action/ with fire suppression within Bitterroot Front Landscape

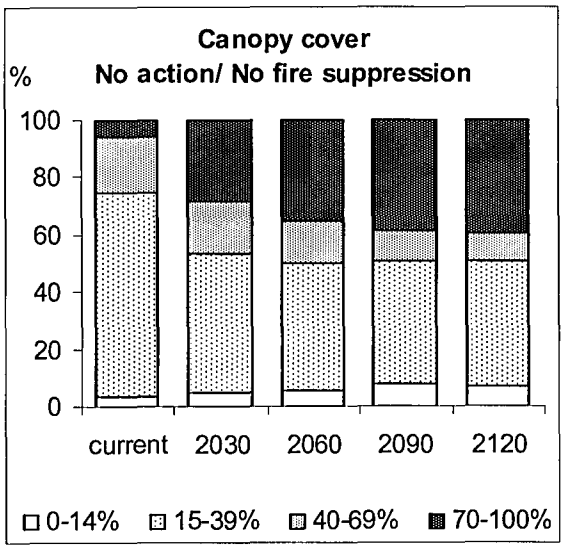

Figure 8. Stacked bar charts comparing canopy cover distribution over 5 time periods for alternative scenario no action/ no fire suppression within Bitterroot Front Landscape

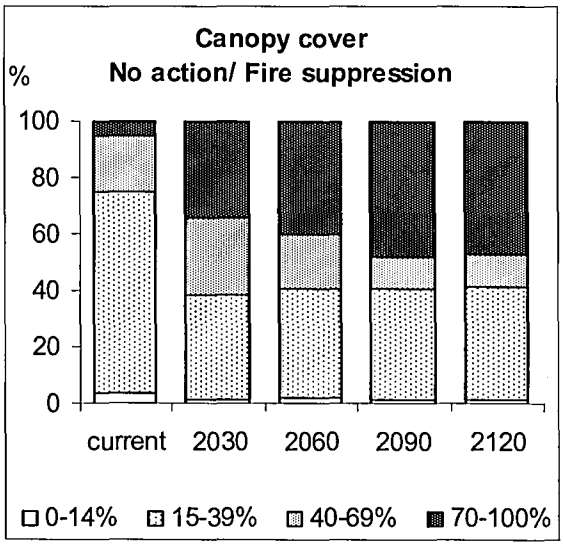

Figure 9. Stacked bar charts comparing canopy cover distribution over 5 time periods for alternative scenario no action/ with fire suppression within Bitterroot Front Landscape

B. Ecological restoration alternative

"A science of land health needs, first of all, a base datum of normality, a picture of how healthy land maintains itself as an organism."
Aldo Leopold, 1942

Natural disturbance processes create biodiversity within the historical range of variability (Brown, 1995), and thus affect the composition and spatial distribution of ecological communities (Haufler et al., 1996). The ecological restoration alternative aims to re-establish landscape features, that is, patterns and processes, which existed prior to the Euro-American settlement era beginning about 1900. This point in time marks the beginning of significant changes in forest management, particularly fire control (Agee, 1990), that had major and long term impacts on the currently (2000) existing vegetation conditions. The best quantitative reference for these early vegetation conditions is a publication by Losensky (1997), specifically his description of section

M332B, which encompasses the Bitterroot-Blackfoot area and integrates the previous history of the area, primarily settlement and land-use by Native Americans. Specific objectives are the

1. restoration of tree species composition/ cover types (exhibited by % cover)
2. restoration of density/ size structure
3. re-establishment of historic disturbance processes

In the framework of this study a desired future condition is achieved if crucial natural disturbance processes, primarily fire, are brought back or the effects on the forest structure at least imitated. Restoration silviculture that favors a particular cover type/ species is closely related to a set of specific structure types. The discussion of cover type and structure type restoration as a result and its effects on disturbance processes is directly linked and has to be viewed synoptically. However, the complexity of landscape patch characteristics – landscape process interactions cannot be fully described in this context.

Restoration of historic cover types

Present conditions of the forest structure and cover types reflect the wildfire suppression policies commonly applied for decades. Fuel accumulations and shifts in species composition are observed (Society of American Foresters, 1993).

Some species-level detail was lost through the aggregation process inherent to the classification system (i.e. Losensky's cover types "Sub" and "Other"). However, the comparison of existing and historic conditions reveals some significant discrepancies (Table 16). The non-forested area, which Losensky (1997) describes as dominated by bluebunch wheatgrass and rough fescue on low and drier sites and by rough fescue and Idaho fescue in moister upper valley locations, remains unchanged at 20%. In the forested area (Figure 10), Lodgepole pine as the previously dominant cover type shows a significant decline, while Ponderosa pine, Douglas fir, Western larch and Subalpine types, as well as riparian types with Cottonwood, Grand fir and Quaking aspen increase.

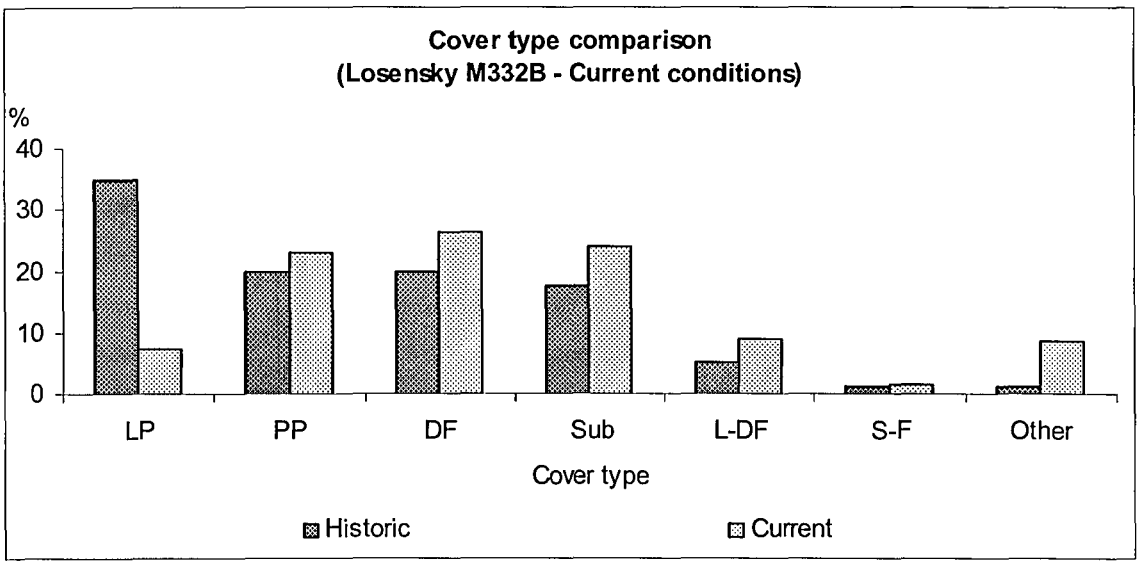

Figure 10. Comparison of historic vs. current cover type distribution within the Bitterroot Front Landscape (Losensky 1997 classification)

Table 16. Relationship between historic and current cover types within the Bitterroot Front Landscape (normalized)

Cover type (Losensky)	Losensky [%]		Current [%]		Difference [%]	
	effective	normalized	effective	normalized	effective	normalized
LP	28	35	6	7	-22	-28
PP	16	20	19	23	3	3
DF	16	20	21	26	5	6
Sub	14	18	19	24	5	7
L-DF	4	5	7	9	3	4
S-F	1	1	1	2	0	0
Other	1	1	7	9	6	8
NF	21		20		-1	

effective = vegetated area (without water, barren land, agriculture), 100% = 362,442 acres
normalized = forested area only (without non-forest land types), 100% = 291,192 acres

Many stands with traditionally fire-maintained regeneration cycles and resulting structure types as well as fire adapted tree species are replaced or dominated by shade-tolerant Douglas-fir (Brown, 1995). Although this is the theoretical climax condition for the moist Douglas-fir sites most abundant for the study area (Fischer & Bradley, 1987), short natural disturbance cycles

established open park-like mixed stands of Douglas-fir, Ponderosa pine, Lodgepole pine and Western larch in the lower elevations. In higher elevations and the subalpine zone, fires are infrequent but severe, and with long-lasting effects (Fischer & Bradley, 1987).

The significant decrease of Lodgepole pine types can be attributed to mortality of older Lodgepole pine stands and fire suppression, preventing Lodgepole pine stand replacement fire events which favored the regeneration of more shade-tolerant species like Douglas fir and Subalpine fir as Lodgepole pine died from beetle mortality. This was probably most effective in stands in fire group 7 (Figure 2) which are fire-maintained with Lodgepole pine as dominant seral species or persistent dominant (Fischer & Bradley, 1987). Similarly the suppression of infrequent large scale - high intensity fires in the cooler and moister habitat types at higher elevations resulted in successional replacement of shade-tolerant tree species with a low degree of fire resistance, like Spruce and Subalpine fir.

A study conducted by Hartwell et al. (2000) "comparing historic and modern forests on the Bitterroot Front" found some contrary trends to these findings. On sampling grids along three forested east sloping ridge faces, Lodgepole pine increased its relative percentage of basal area, while Ponderosa pine, Western larch and Whitebark pine declined (Hartwell et al. 2000). However, several reasons could explain this discrepancy: The crosswalk of SIMPPLLE cover types, whose labels are not in order of species dominance, to Losenskys cover types, decreases detail. Further, Losenkys estimates, unlike Hartwell et al.'s (2000) study, are not based on basal area of single species but on percent cover of highly aggregated cover types. Compared to the range of biophysical conditions of the study area encompassing the entire Bitterroot Front, the limited set of ecological conditions on predominantly east facing slopes in Hartwell et al.'s (2000) study might well be a reason for differences over all trends.

Concerning the restoration of historic cover types, the management prescription of stand replacing fires (or clear-cutting) would favor fire-dependent seral species like Lodgepole pine, Ponderosa pine and Western larch. Moderately open conditions achieved by selective harvesting

of larger seral trees would retain partial shade and favor shade tolerant tree species like Douglas-fir, Grand fir and Subalpine fir (Fischer & Bradley, 1987).

Restoration of historic structure types

The achievement of restoring historic structure types is not as straight forward as the methods for restoration of Losensky's historic cover types. Three major problems arise: namely differences between SIMPPLLE and Losensky in the classification of tree size, a lack of historic canopy layering information, and a lack of historic data for stand densities.

Compared to a fairly even distribution of the four size classes prior to 1900 (Table 17 and Figure 11), the current conditions do not contain sufficient stands in "seedling/ sapling" as well as "very large" stages and show a prevalence of mid-seral size classes "Pole" and "Mature".

Table 17. Quantitative comparison between SIMPPLLE and Losensky (modified) size class definitions

SIMPPLLE size classes	%	Losensky size classes	%
non-stocked	4	non-stocked	3
Seedl./Sapl. (<5")	10	Seedl./Sapl. (1-40 yrs.)	21
Pole (5"-9")	27	Pole (41-100 yrs.)	26
Medium (9"-15")	11		
Large (15"-21")	31	Mature (101 yrs. - OS)	23
Very Large (>21")	17	Old stands (OS+)	28

[1]Pfister, personal communication

Density estimates for the ancient forest landscape based on their stand habit (Fischer & Bradley, 1987) indicate that roughly 16% had open canopies, 60% showed moderate-dense canopies and 24% had closed canopy characteristics (Table 18).

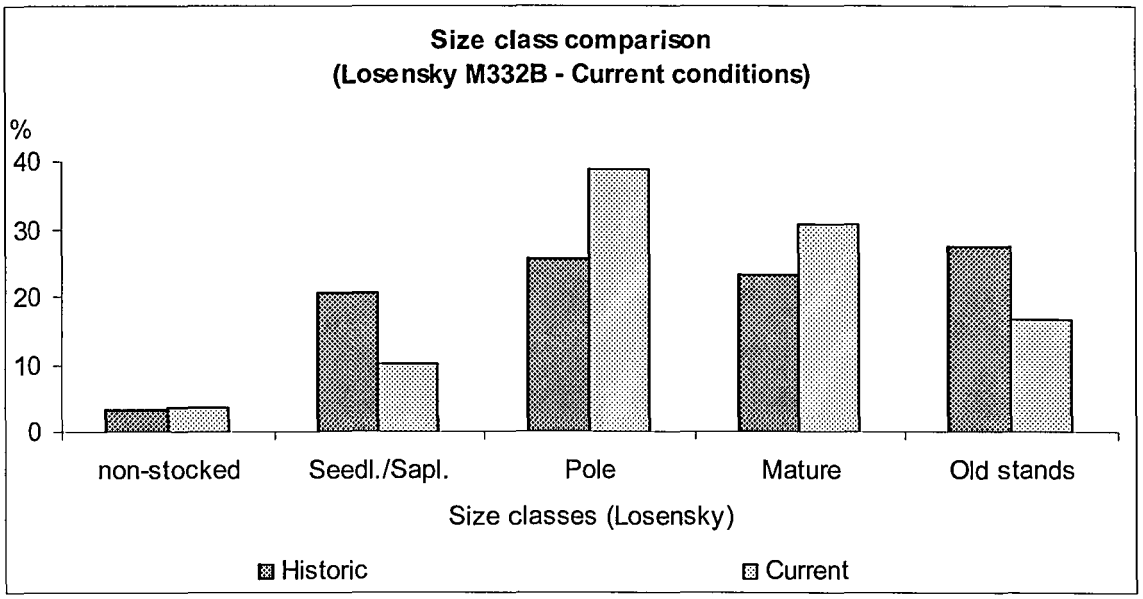

Figure 11. Grouped bar charts comparing historical and current size class distributions in Losenskys classification within the Bitterroot Front Landscape

Table 18. Canopy cover class acreages and percent by stand habit based on fire groups (Fischer & Bradley 1987) within the Bitterroot Front Landscape

Stand Habit	Acres	%
Dense	69,905	23.8
Moderate-Dense	176,846	60.3
Open-Moderate	939	0.3
Open	45,439	15.5

The fact that about 50% of the forested areas, primarily in the lower elevations (Map 11), are in fire groups with natural fire return intervals of 50 years and less (Table 19) suggests, that this portion of the landscape could be assigned a multistory structure type, and be maintained through uneven-aged management (Pfister, personal communication, 2000). Examples of these uneven-aged prescriptions exist on 20-year old research demonstration sites at Lubrecht Experimental Forest and a 35-year old case study on the Flathead Indian Reservation. Studies on these sites demonstrate that selective cutting methods are suitable tools to emulate the environmental conditions typical for low intensity/ high frequency disturbance regimes (Arno & Fiedler, 2005). For occurrence of stands on the landscape suitable for uneven-aged and even-aged

Table 19. Proportion of fire groups and according management types within the Bitterroot Front Landscape

Fire group	Acres	% forested area	Fire type	Fire ret. interval (yrs)	Managmt. type
2	9,616	3.3	low severity	5-25	Uneven-aged
4	939	0.3	low severity	5-25	Uneven-aged
6	128,611	43.9	mixed severity	40	Uneven-aged
7	35,823	12.2	mixed severity	<100-500	Even-aged
9	68,886	23.4	high severity	>120	Even-aged
10	48,235	16.6	high severity	>200	Even-aged
11	1,019	0.3	high severity	100 - >200	Even-aged

Based on Fischer & Bradley 1987

management regimes see Map 12. Special management areas are assigned additionally to address riparian management considerations in stands of cottonwood and quaking aspen cover types under existing conditions.

Restoration silviculture for Ponderosa pine and Western larch would open a stand enough to allow shade intolerant species regeneration, e.g. 40-60 square feet/acre of stand basal area (Fiedler, 1996). Creating scattered small openings would promote the regeneration of Ponderosa pine while groups of very large trees are left intact thus forming a multistory stand (Fiedler, 1996).

A study by Hardy et al. (2000) on the Interior Columbia Basin Ecosystem Management Project addressing an "Ecosystem-based management in the Lodgepole pine zone" compared historical and current forest landscapes. Their findings describe larger, more irregular patches with higher diversity prior to 1940. Subalpine fir was less abundant while pine was more abundant than on the current landscape. In general, today's forests display more "later structural stages with over 80 percent of the landscapes being older than seedling/sapling" (Hardy et al., 2000). Their proposal is a silvicultural treatment system for Lodgepole pine restoration that retains leave trees in two distinct forms: one in an even distribution, and one resembling the uneven pattern/ clumps of mixed severity burns, while removing 50% of initial basal area across diameter classes (Hardy et al., 2000).

Map 12. Spatial distribution of assigned management types within the Bitterroot Front Landscape

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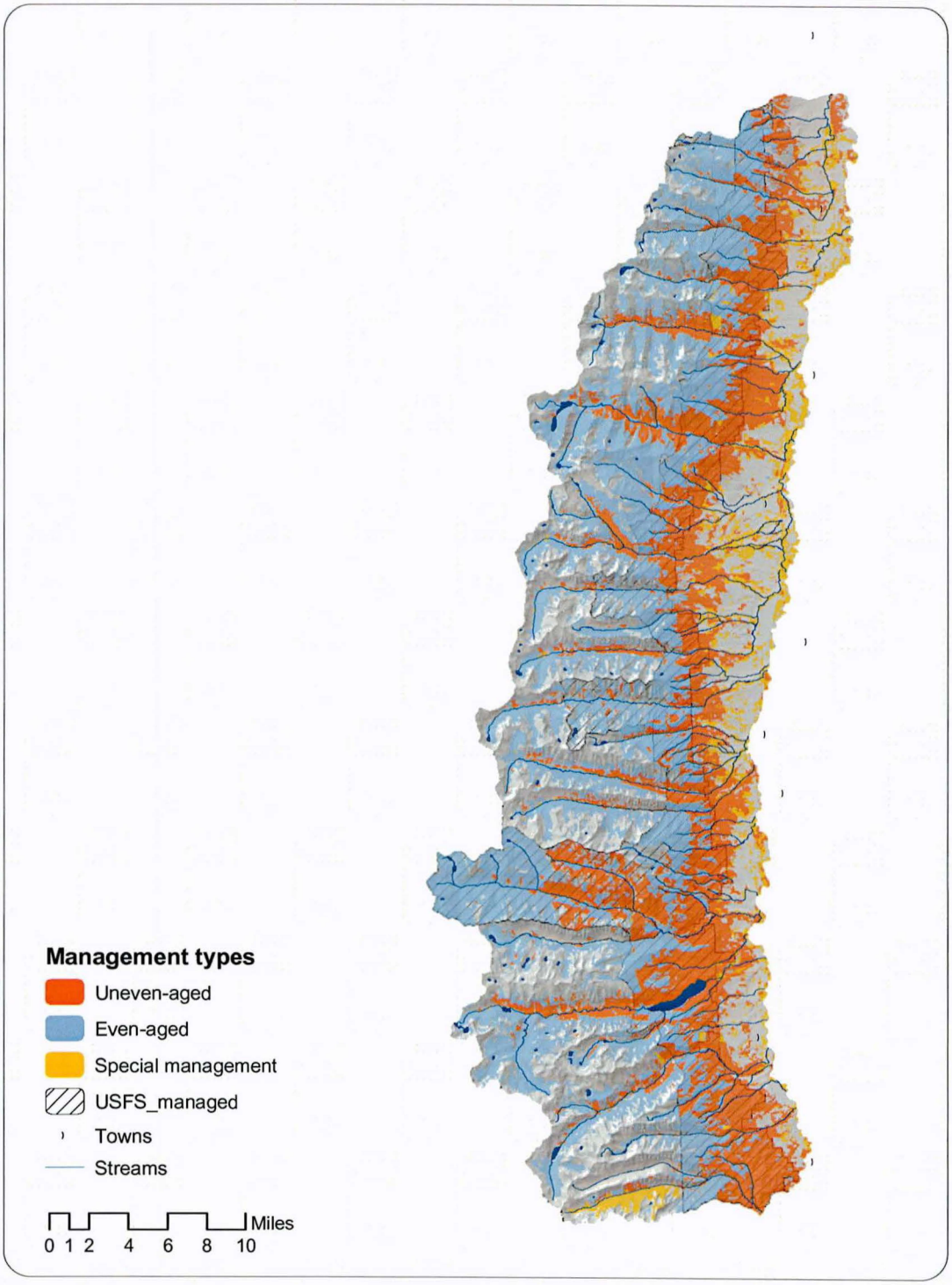

Taking into account the historical data of cover type and occurrence (Losensky, 1997) (Figure 10), and the maintenance of a fire related forest structure (Fiedler, 1996; Fischer & Bradley, 1987; Hardy et al., 2000), the desired proportion of structure types was developed. At the end of the projection period, the following size classes will result: seedling/ sapling 21%, pole 13%, medium 13%, large 22% and very large 28% (Table 20). In all but the Seedling/Sapling size class 50% each are assigned to even-aged or uneven-aged management.

Table 20. Summary of Desired Future Conditions (Structure types) for the Ecological restoration alternative

Density class	Size class	non stocked	Seedl./ Sapl. 0"-5"	Pole 5"-9"	Medium 9"-15"	Large 15"-21"	Very Large >21"	Total canopy	
70-100%	EA	0%	9%	2%	2%	5%	6%	24%	39%
	UEA	0%	0%	2%	2%	5%	6%	15%	
40-69%	EA	0%	9%	3%	3%	4%	6%	25%	43%
	UEA	0%	0%	4%	4%	4%	6%	18%	
15-39%	EA	0%	3%	1%	1%	2%	2%	9%	15%
	UEA	0%	0%	1%	1%	2%	2%	6%	
0-14%		3%	0%	0%	0%	0%	0%	3%	
Total size class		3%	21%	13%	13%	22%	28%		100%

EA = even-aged management; UEA = uneven-aged management

Restoration of historic disturbance processes

The third component of the implementation of the ecological restoration alternative is the re-establishment of historical disturbance patterns and a differentiation between disturbed and undisturbed sites. Mimicking the natural disturbance cycles includes prescribed fire regimes as well as silvicultural treatments. Clearcuts show resemblance in forest structure and can mostly act as substitution for high-intensity, low-frequency stand replacing fires; thinning and partial harvest prescriptions can imitate the forest structure of low-intensity, high-frequency underburns (Haufler et al., 1996, Arno & Fiedler, 2005). Neither can, however, replicate the entire range and quality of ecological properties natural disturbance regimes would create (Franklin et al. 2002), unless modified to accommodate disturbance specific landscape features, e.g. biological

legacies, irregular patch shapes, frequency of disturbance (Lindenmayer & Franklin, 2002). Successional stages larger than pole size are less susceptible to low and moderate intensity fires, thus fires will thin the stand and initiate regeneration (Fischer & Bradley, 1987).

Fiedler's (2002) "natural process-based management of fire-adapted western forests" promotes silvicultural treatments to achieve a forest structure that emulates the effects of natural fire-regimes and is considered a prerequisite to the "reintroduction of fire as an ecological process". With a focus on the removal of the small-tree component, Fiedler (2002) demonstrates an approach "for addressing altered conditions in fire-adapted forests", that integrates the conventional thinning-from-below treatment with selection cutting. Identified management targets are low to moderate density, large-tree dominance and uneven-aged structure for short-interval fire adapted forest, e.g. primary forest types of Ponderosa pine, pine/ fir and dry mixed conifer (Fiedler, 2002). For Lodgepole pine regeneration, Hardy et al. (2000) propose a treatment schedule that would imitate a combination of mixed and high severity fire regimes. With stand-replacing fires occurring in 100-300 year intervals, low- and mixed severity fires usually interrupted these otherwise long cycles without fire, creating a more clumped distribution (Hardy et al., 2000).

An example for restructuring the pre-settlement and fire-maintained tree species proportions according to the referred Bitterroot-Blackfoot section of Losensky (1997) is displayed in Figure 12. Naturally, Lodgepole pine covered more extensive areas than it does today. Prescribed stand replacement fires are most likely to re-establish Lodgepole pine cover types as the specie's "key fire survival attribute is cone serotiny" (Fischer & Bradley, 1987). The heat of a fire is necessary to melt the resin of serotinous cones and make the seed available. Stand replacing fires, killing all species would create following pure Lodgepole pine stands if serotinous cones were present (Fischer & Bradley, 1987).

A light understory fire for large Douglas-fir trees in a stand means 'stand replacement fire' for the understory vegetation of the same stand (Brown, 1995). Natural fire tempers the regeneration

cycles of shrubs, forbs and grasses in much shorter intervals than for trees. However, changes in overstory structure manifest themselves in changes of the understory vegetation as well.

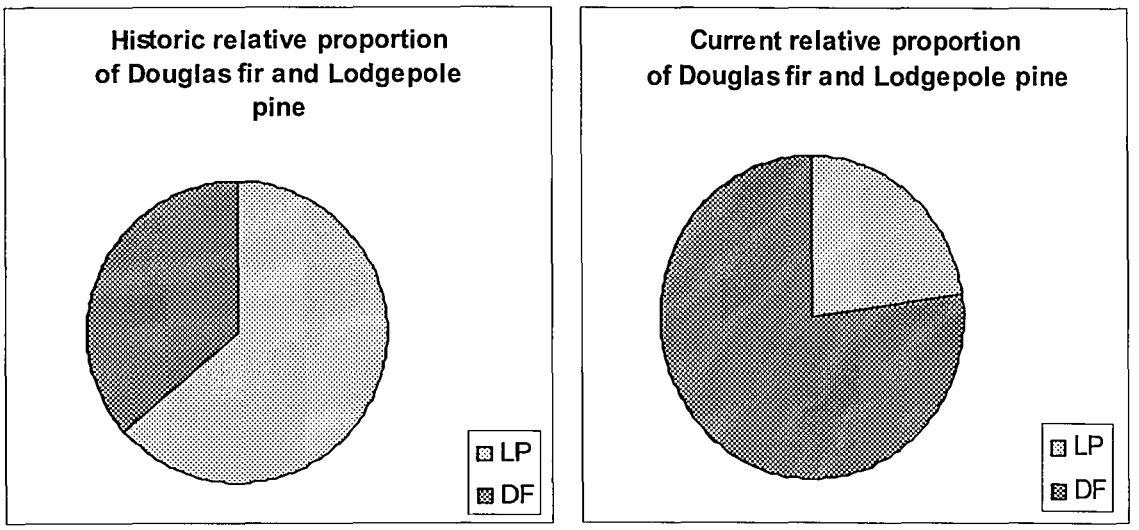

Figure 12. Historic and current relative proportion of Douglas fir and Lodgepole pine for the Bitterroot Front Landscape

C. Ecological diversity alternative

Pre-European settlement forests in the United States were exceedingly dynamic, highly diverse and shaped by many natural and human influences, disturbances and catastrophic events, creating splendid wildlife variety and abundance (MacCleery, 2002). The ecological diversity alternative addresses this spatial heterogeneity of landscape features as prerequisite for the diversity of known and unknown plant and animal species as well as processes. Consequently, management considerations should create maximum beta-diversity in terms of comparing diversity among ecosystems. Measured as species response to ecosystem diversity (Whittaker, 1972), the goal is to maintain a full range of variability of vegetation and process conditions for various species and developments.

Ecological diversity is considered to be a "key part of sustaining long-term forest productivity" (Society of American Foresters, 1993). For the study area, the diversity is addressed with a

coarse filter approach, which seeks to achieve maximum beta-diversity. As Forman (1995) states, the "context is usually more important than content". The large spatial extent, range of elevation as well as variability of site conditions of the study area provides a representative example of the Bitterroot National Forest and the ecological context to understand, quantify and evaluate inherent ecosystems maintaining "viable populations of all native species dependent on those ecosystems" (Haufler et al., 1996).

Using an ecosystem diversity matrix comprised of vegetation growth stages and habitat type groups as a tool, Haufler et al. (1996) developed an ecosystem management process as a "coarse-filter approach with species assessment." Its partitions for an appropriate classification of the landscape follow ecological, biological, and operational similarities (Haufler et al., 1996) rather than administrational or geographical boundaries. In a simplified example for this study, well-studied habitat characteristics of large mammals like elk and deer will provide the parameters for a fine-filter species assessment for using vegetation patterns as a "coarse-filter" approach to design a landscape that promotes ecological diversity (Kangas & Pukkala, 1996). As the term 'coarse-filter' implies, this approach attempts to maintain and enhance ecosystem structure and composition to emphasize ecological communities rather than species-specific habitat needs (Haufler et al., 1996).

The comprehensive ecosystem diversity matrix addressed by Haufler et al. (1996) categorizes into habitat type groups, vegetation growth stages, dominance of overstory vegetation (in %), and disturbance regimes. However, parameters included in the matrix for this study are limited to size class and density, which imply the integration of successional vegetation pathways.

The key features that are related to the forest structure types (which are part of the ecosystem diversity matrix) are the availability of forage, visual hiding cover and thermal cover for elk and deer and are used as an example of the usefulness for this general approach (fine-filter species assessment). With this idea in mind, a functional linking of forest structure types and

habitat characteristics is proposed in Table 21. It was adapted after a previous version of this table, developed for Lubrecht Experimental Forest during a class exercise in the fall of 2000. Habitat characteristics are not mutually exclusive and may be represented by multiple vegetative structure types. The resulting proportions of vegetative structure types on the landscape are normalized to sum to 100%. Non-forested areas (~15% of the total area) like grassland, shrublands and alpine meadows are factored in as potential forage habitat in the formulation of this desired future condition.

Table 21. Functional linking of current vegetation structure types and habitat characteristics

Structural classification			Habitat characteristics		
Size class	Density class	% of vegetated area	Forage	Hiding cover	Thermal cover
Seed/Sap	15-39%	7.5	Yes	No	No
Seed/Sap	40-69%	0.5	Yes	No	No
Seed/Sap	70-100%	0.2	No	Yes	Yes
Pole	15-39%	15.6	Yes	No	No
Pole	40-69%	4.6	Yes	No	No
Pole	70-100%	1.9	No	Yes	Yes
Medium	15-39%	4.7	Yes	No	No
Medium	40-69%	3.9	Yes	Yes	No
Medium	70-100%	0.7	No	Yes	Yes
Large	15-39%	21.9	Yes	No	No
Large	40-69%	2.6	Yes	Yes	No
Large	70-100%	0.5	No	Yes	Yes
Very large	15-39%	8.1	Yes	No	No
Very large	40-69%	4.5	Yes	Yes	No
Very large	70-100%	1.0	No	Yes	Yes
Non-Stocked	0-14%	3.0	Yes	No	No
Non-Forested	0-14%	18.9	Yes	No	No
UEA	15-39%	-	Yes	No	No
UEA	40-69%	-	Yes	Yes	Yes
UEA	70-100%	-	No	Yes	Yes

UEA = uneven-aged/ multi-storied

Open and moderate dense stands provide the best forage availability, as the overstory allows shrubs and herbaceous vegetation to grow on the ground. With increasing tree canopy density, the understory vegetation decreases and such sites qualify as hiding cover because the

presence of vertical vegetation results in visual obstruction. Hiding cover is formed by vegetation capable of screening 90% of an adult standing elk or deer at 200 ft or less (Thomas et al., 1979). It provides protection from predators, allowing for a more efficient utilization of the animals range. Hiding cover is also influenced greatly by vertical structure – single story vs. multistory – complicating the problem. Stands that have been thinned or underburned probably provide little hiding cover, even though density may be moderate. Optimum thermal cover for elk is provided by stands of trees 40 feet or taller and with a crown cover of 70% or more, smoothing temperature extremes both in summer and winter (Thomas et al., 1979). For deer, shrubs and trees 5 ft tall and above and a crown closure of 75% supply an effective thermal cover as well. Multi-storied stands are considered most favorable, due to their ecological stability. The composition of several tree species of various ages provides some protection against catastrophic loss (Thomas et al., 1979) and hence makes them more resilient to total loss due to disturbance processes.

The existing high amount of open forest stands (~ 72%) provides an excessive abundance of forage ground, while at the same time limiting the availability of visual and thermal cover features. While the highest diversity of habitat characteristics appears to occur on US Forest Service manageable land, wilderness area and private lands commonly have a far more homogeneous appearance in terms of habitat characteristics (Map 13). Most of the wilderness area is in the subalpine zone, which generally provides high hiding and thermal cover in the forested portion, while the private land is in the lower montane zone, with generally lower availability of hiding and thermal cover. The reasons for the distinct distribution on the landscape could be manifold. While possibly attributable to past management activities another reason could be the availability of accurate data or lack thereof for private lands and the wilderness area.

The ecological diversity alternative seeks to establish a diverse landscape in a mosaic of patches of various sizes with the proportion of the different structure types designed to provide an adequate ecological representation of each cell in the ecosystem diversity matrix (Haufler et al.,

Map 13. Spatial distribution of habitat characteristics within the Bitterroot Front Landscape

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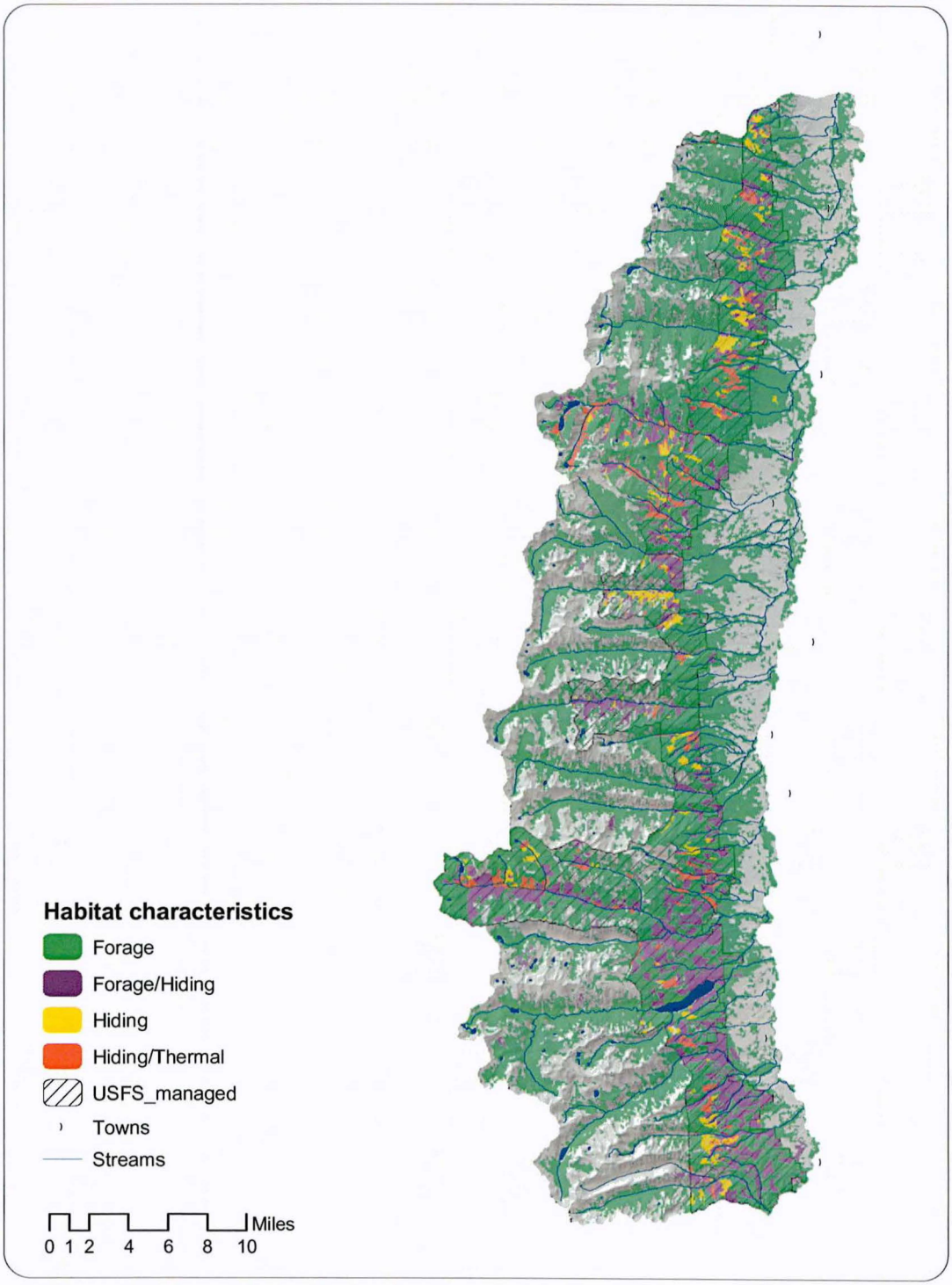

1996). All but closed canopy cover types provide forage availability; increasing tree size and density of the canopy cover changes the conditions to hiding cover and thermal cover in late seral phases. Neighboring patches accommodate varying structure types, thus serving different habitat needs at closer spatial proximity (Forman, 1995). Considering a separate habitat characteristic like e.g. 'hiding cover' reveals, that patches of a similar attribute are linked to form larger compounds and corridors. In addition to the increased combination of patch structures, the higher structural diversity increases the frequency of edges as linear landscape elements and as habitat itself (Rosenberg et al., 1997).

Intended treatments towards ecological diversity would break up large homogeneous patches and foster increased heterogeneity and landscape complexity. By breaking up existent large tracts of dominant structure types with patches of dissimilar structure types, habitat characteristics would become spatially and quantitatively more evenly available according to their adequate ecological representation (Haufler et al., 1996).

Based on habitat needs Thomas et al. (1979) provide guidelines on the optimum quantitative and spatial mix of structural stages on a landscape for elk and deer, with 60% appropriate as forage area, 20% hiding cover, 10% thermal cover, and 10% hiding or thermal cover. Size, shape, proximity, and contagion, among other patch attributes, are additional important factors considering habitat feasibility but are not addressed at this scale. However, they should be addressed for smaller areas during the implementation process.

The existing and future proportions of several habitat characteristics for the study area's vegetation (361,422 acres) are illustrated in Figure 13. The no-action categories describe the habitat characteristics according to the landscape conditions as simulated by SIMPPLLE for the year 2120, while the desired future conditions (DFC) display the management target conditions.

Changes in overstory structure influence changes in the understory vegetation and availability of forage production. Existing conditions display an abundance of forage areas and low availability of hiding cover and thermal cover (Figure 13).

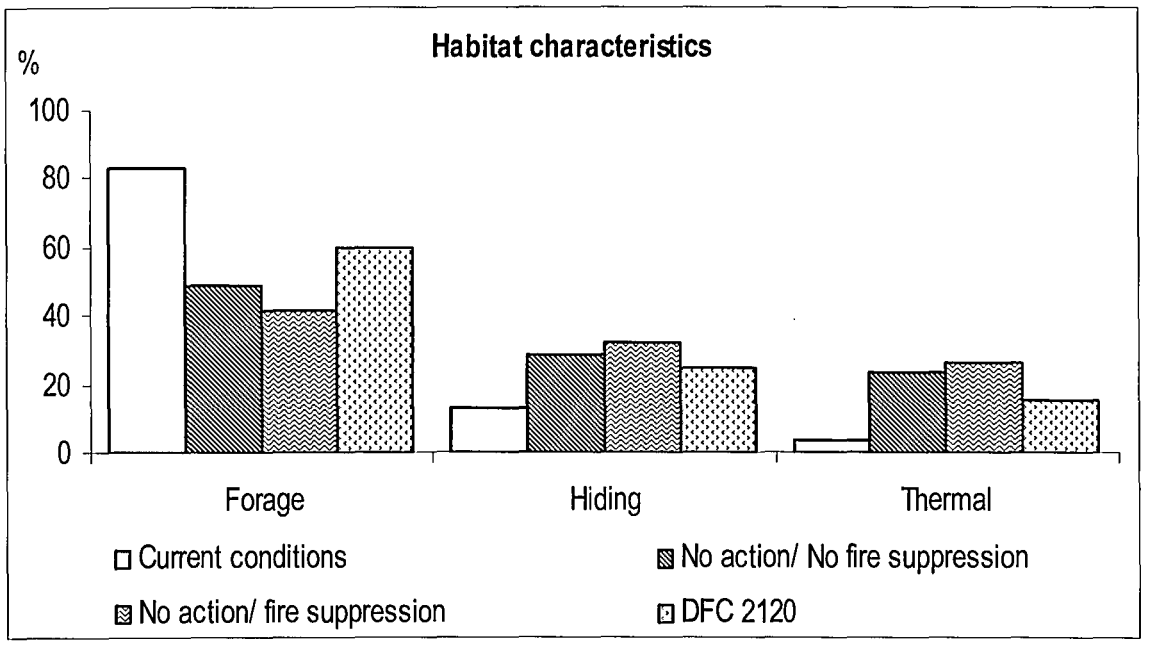

Figure 13. Comparison of the proportion of three habitat characteristics by four conditions for the Bitterroot Front Landscape

Both no-action alternatives would increase canopy densities and thus at least double hiding cover as well as thermal cover at the expense of forage areas. The desired future condition management target balances these parameters according to the defined habitat needs.

Taking into account the adequate ecological representation in the ecosystem diversity matrix (Haufler et al., 1996), and the optimum mix of structure types (Thomas et al., 1979), a desired proportion of structure types was developed. At the end of the projection period, the size classes will be distributed as follows: seedling/ sapling - 22%, pole - 13%, medium - 13%, large - 15%, very large - 15%, and uneven-aged/multistory - 22% (Table 22). About one third of the forested area (293,129 acres) (35%) will have open canopy, 46% will have moderately dense canopies and 19% will have dense or closed canopies.

Table 22. Summary of Desired Future Conditions (Structure types) for the Ecological diversity alternative on the Bitterroot Front Landscape

Size class / Density class	ns/nf	Seedl./ Sapl. 0"-5"	Pole 5"-9"	Medium 9"-15"	Large 15"-21"	Very Large >21"	UEA	Total density
70-100%	0%	2%	3%	3%	3%	3%	5%	19%
40-69%	0%	17%	8%	8%	4%	4%	5%	46%
15-39%	0%	3%	2%	2%	8%	8%	12%	35%
0-14%	0%	0%	0%	0%	0%	0%	0%	0%
Total size class	0%	22%	13%	13%	15%	15%	22%	100%

For effective management that addresses biodiversity, additional landscape features need to be considered, e.g. large snags and down woody debris are critical habitat components for many wildlife species. These are most common in old stands with senescent trees and patches that remained largely undisturbed. During the implementation process additional patch characteristics like edge ratio, interspersion and juxtaposition as well as size and shape can be addressed project by project on sub-landscapes, e.g. HUC 6 watersheds. For example Fischer & Bradley (1987) found, that e.g. blue grouse is a fire-dependent bird species that needs "medium-to-large fire created openings with shrub-grass-forb vegetation for breeding adjacent to dense foliage conifers for roosting and hooting".

D. Sustainable timber production alternative

The sustainable timber production alternative aims to achieve or mimic the timber revenue goals stated in the management goals and objectives for the Bitterroot National Forest by establishing long-term stability in timber production, providing "sawtimber and other wood products to help sustain a viable local economy" as well as "firewood for personal and commercial use" (Bitterroot National Forest, 1987). Fiedler (2002) defines sustainable forest conditions with respect to their reasonable resistance to fire and diseases, the periodic regeneration of seral species, their promotion of the vigor and development of large trees as well as productive and diverse undergrowth plant communities. Further goals are an adequate amount

of stands with trees in the very large size class as a precious forest constituent (Langston, 2000), the conversion of "high-risk or insect and disease infested stands to young, healthy stands" and to "achieve a species mix of offered volume that is nearly proportional to standing inventory" (Bitterroot National Forest, 1987).

As a point of reference, the Forest Plan for the Bitterroot National Forest (1987) established size class distribution goals at the end of decades one (1986 - 1995) and five (2026 - 2035) (Table 23) to achieve its stated objectives. The two size classes, medium and large, are aggregated into a single size class (immature and mature) sawtimber. The difference of 5,100 acres in the total acreage is unaccounted for. The most significant projected changes are an acreage increase in seedling/ sapling stands and a decrease in stands having very large size classes. Timber harvest yield is estimated to be 33.4 million board feet per year for decade 1 and 43.0 million board feet per year for decade 5. The Forest Plan establishes that "about 68% of the volume will have been harvested using the clearcut system, 28% by shelterwood and 4% by other methods" (Bitterroot National Forest, 1987).

Table 23. Estimated acreage distribution by size classes for decades 1 and 5 from BNF management plan (1987)

Size class	Acres (1^{st} decade)	%	Acres (5^{th} decade)	%
Seed/Sapl	56,000	16	81,600	23
Pole	57,000	16	55,900	16
Medium/Large	104,000	29	113,100	32
Very large	144,000	40	105,300	30
Total	361,000	100	355,900	100

Medium/Large = immature /mature sawtimber

A comparison of size class distributions for existing conditions (year 2000) and the two no-action alternatives (without and with fire suppression) simulated with SIMPPLLE for the year 2030 (based on 291,129 acres of forested land) as well as the stated goals of the BNF Forest Plan for decades 1 (based on 361,000 acres of suitable timberland) and 5 (based on 355,900 acres of

suitable timberland) is provided in Figure 14. While both no-action alternatives would significantly decrease the proportion of stands in the very large size class, compared to the existing conditions, the stated management targets in the Forest Plan (Bitterroot National Forest, 1987) would increase its proportion on the landscape while decreasing the amount of stands in pole, and medium/large (= immature and mature sawtimber) size classes.

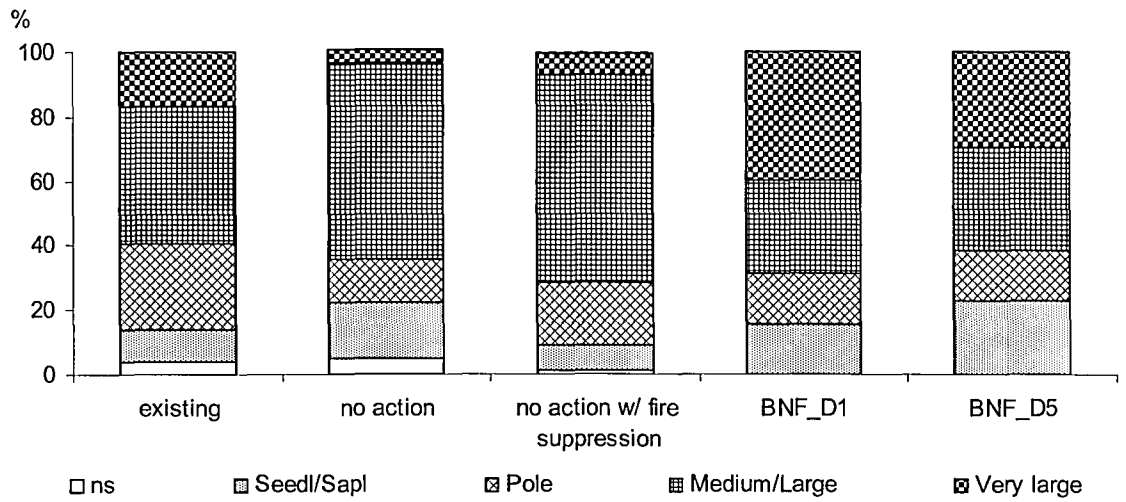

Figure 14. Stacked bar chart comparing the size class distributions for existing conditions, no-action alternatives (year 2030) and Forest Plan management targets Decades 1 and 5 for the Bitterroot Front Landscape

Based on habitat type groups (Pfister et al., 1977), the potential timber yield capability of a stand can be estimated by mean annual increment (MAI). 80% of the forested areas (293,129 acres) have high (85-120 ft3/acre/year) and moderate (50-85 ft3/acre/year) yield capabilities, and 20% have low (20-50 ft3/acre/year) and very low (<20 ft3/acre/year) yield capabilities (see Table 15 for details). With moderate potential yield stands most abundant, high potential yield stands are found mainly on north-facing slopes of the major east-west running valleys, while low and very low potential yield stands occur at higher elevations and some southerly exposures (Map 14). Management activities would have to be located accordingly to balance annual timber yield and ecological as well as technical constraints.

Map 14. Spatial distribution of potential yield capability within the Bitterroot Front Landscape

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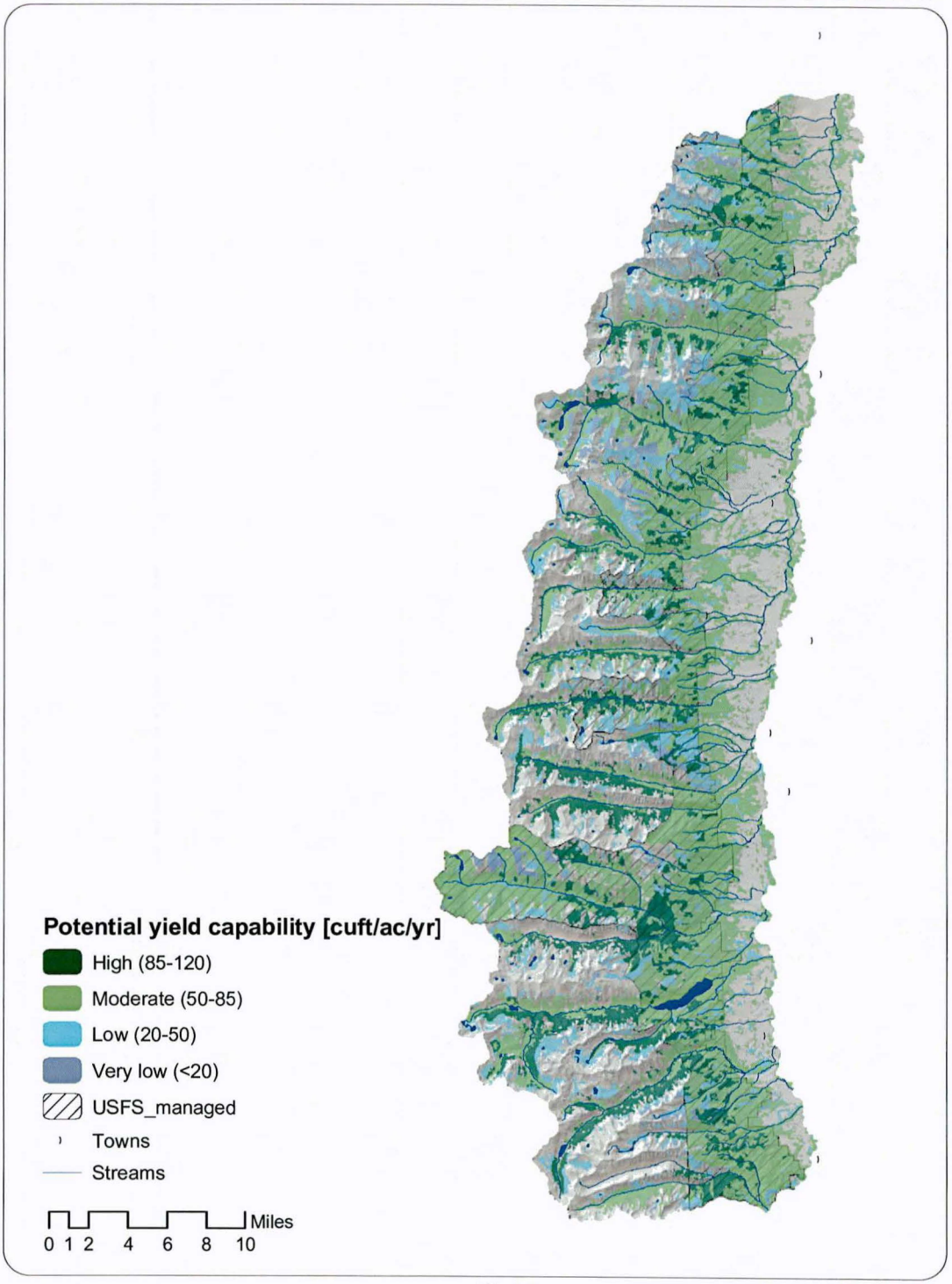

An estimation of potential annual timber yield by habitat type group can then be derived by multiplying the average of the estimated mean annual increment (MAI) by the corresponding acreage (Table 24). The potential annual increment (AI) for the forested area is roughly 17,423 Mcft, or 104,541 Mbft (using a 1:6 cuft:bdft ratio).

Table 24. Estimated potential timber productivity by habitat type group for wilderness and non-wilderness area (based on Pfister et al., 1977)

Habitat type group	Estimated MAI [cuft/ac/yr]	Forested acres		Estimated AI[Mcft]		Estimated AI[Mbft]	
		non-wilderness	wilderness	non-wilderness	wilderness	non-wilderness	wilderness
A2	28.5	8,700	916	248.0	26.1	1,487.7	156.6
B1	59	504	435	29.7	25.7	178.4	154.0
B2	61	98,980	17,408	6,037.8	1,061.9	36,226.7	6,371.3
B3	63	99	178	6.2	11.2	37.4	67.3
C1	87	10,735	1,211	933.9	105.4	5,603.7	632.1
C2	108	623	396	67.3	42.8	403.7	256.6
D2	32	-	7	-	0.6	-	3.8
D3	81	13,935	24,979	1,128.7	2,023.3	6,772.4	12,139.8
E2	73	13,735	16,230	1,002.7	1,184.8	6,015.9	7,108.7
F1	57.5	27,120	8,703	1,559.4	500.4	9,356.4	3,002.5
G1	33	11,194	27,922	369.4	921.4	2,216.4	5,528.6
G2	15	2,360	6,759	35.4	101.4	212.4	608.3
Total		187,985	105,144	11,418.5	6,005.0	68,511.1	36,029.7

Conversion factor: cuft/bdft ratio = 1/6

If wilderness area were removed from this summary, the yield capability can be estimated for the non-wilderness portion. Accordingly, 105,144 acres of the total 293,129 acres of forested land are designated wilderness, accounting for 6.0 million cuft (36.0 million bdft) annual timber yield potential with the remaining 187,985 acres having a yield capability of 11.4 million cuft (68.5 million bdft). A long term state-wide analysis of harvest/ inventory relations estimates an average of 1/3 of potential yield capability for unmanaged stands and 2/3 for managed stands (Pfister et al., 1999). Under the assumption that forest stands in designated wilderness are unmanaged, total yield capability is estimated to be 9.6 million cuft or 57.7 million bdft (Table 25).

Table 25. Estimated total yield capability by condition for the forested land of the Bitterroot Front Landscape

Condition	Acres	Million cuft	Million bdft
Wilderness (Unmanaged - 1/3 of yield capability)	105,144	2.0	12.0
Non-Wilderness (Managed - 2/3 of yield capability)	187,985	7.6	45.7
Total	293,129	9.6	57.7

Standing timber volumes can be estimated based on forest structure and habitat types by the multiplication of volume estimates with corresponding acres in an ecosystem diversity matrix comprised of density classes, size classes and habitat type groups. Data for Westside Region 1 were provided by Renee Lundberg (personal communication, 2004) as volume estimates for each combination of habitat type group x size class x density class x dominance type according to Region 1 classifications. Individual volumes were aggregated and averaged using pivot tables and then multiplied by the respective acres for each cell within the ecosystem diversity matrix for existing conditions as well as both no-action alternatives (Table 26).

The selection of treatments and removal levels is adjusted to form a sustained supply of all size classes as well as even-aged and uneven-aged forest structure types. At the end of the projection period of 120 years, 65% of the forested land will be in even-aged, and 35% will be in uneven-aged structure types (Table 27). Combining the uneven-aged and even-aged structure types, each size class results in the following size class distribution: seedling/ sapling 15%, pole 17%, medium 17%, large 17%, and very large 34% (Figure 15). 25% of the forested area will have open canopies, 60% moderate dense canopies and 15% dense canopies. The sustainable timber production alternative is designed to achieve a balanced level of annual increment to generate a steady timber harvest volume and thus revenue across the projected time period. The relatively even distribution of size classes and high proportion of moderate dense stands provides for optimal utilization of space and resources (Fiedler, 1996). The comparatively large amount of

stands in the very large size class permits patches of senescent trees to be retained as well as the production of high-value timber.

Table 26. Summary of standing timber volume estimates for the Bitterroot Front Landscape

	Total cubic feet	Total board feet	Avg. cubic feet/acre	Avg. board feet/acre
Existing conditions	445,823,133	2,674,938,798	1,521	9,125
2120 without fire suppression	479,390,475	2,876,342,848	1,635	9,813
2120 with fire suppression	592,878,407	3,557,270,445	2,023	12,136

Conversion factor: cuft/bdft ratio = 1/6

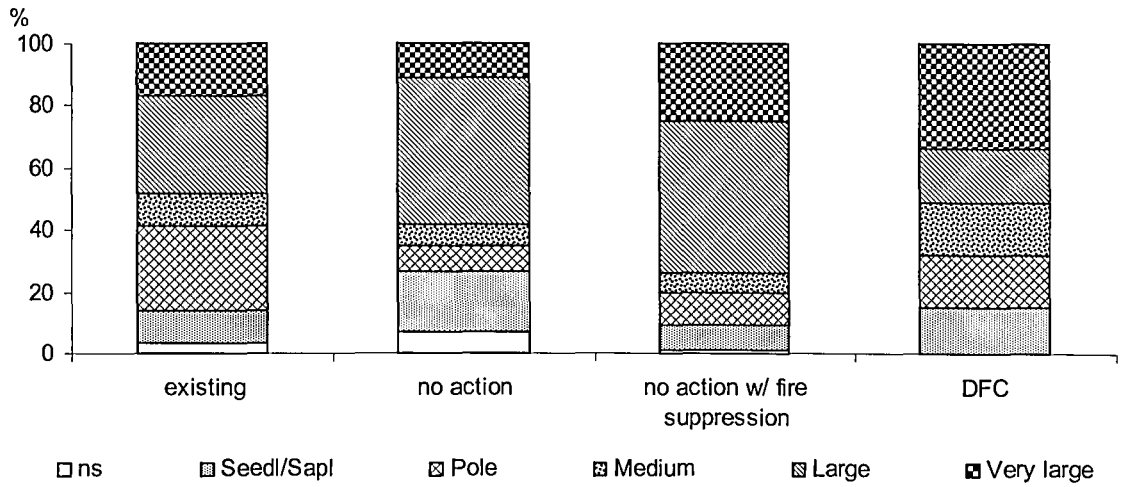

Figure 15. Comparison of size class distributions for existing conditions, no-action alternatives (year 2120) and sustainable timber Desired Future Condition(DFC) for the Bitterroot Front Landscape

Table 27. Summary of Desired Future Conditions for the sustainable timber alternative on the Bitterroot Front Landscape (Structure type matrix) (Acres and %)

Size class / Density class	ns/nf	Seedl./ Sapl. 0"-5"	Pole 5"-9"	Medium 9"-15"	Large 15"-21"	Very Large >21"	UEA	Total density class
70-100%	- 0%	14,656 5%	5,863 2%	5,863 2%	5,863 2%	5,863 2%	5,863 2%	43,969 15%
40-69%	- 0%	29,313 10%	17,588 6%	17,588 6%	17,588 6%	38,107 13%	55,695 19%	175,877 60%
15-39%	- 0%	- 0%	5,863 2%	5,863 2%	5,863 2%	14,656 5%	41,038 14%	73,282 25%
0-14%	- 0%	- 0%	- 0%	- 0%	- 0%	- 0%	- 0%	- 0%
Total size class	- 0%	43,969 15%	29,313 10%	29,313 10%	29,313 10%	58,626 20%	102,595 35%	293,129 100%

The previous ecosystem diversity matrix was reconfigured according to the structure type matrix (Table 28) and each cell was multiplied by the appropriate acreage to estimate standing timber volume for the sustainable timber desired future condition. Since the original matrix did not include an uneven-aged structure type, uneven-aged (UEA) volume was estimated as the average of the volumes from pole size and larger in the associated density classes. Standing timber volumes for the sustainable timber alternative would yield 523.2 million cuft (3,139.2 million bdft) (Table 29), an average of 1,785 cubic feet (10,709 board feet) per acre.

Table 28. Summary of average standing volume estimates for the simplified ecosystem diversity matrix (cubic feet/acre) on the Bitterroot Front Landscape

Size / Density	ns/nf	Seedl./ Sapl.	Pole	Medium	Large	Very Large	UEA
70-100%	-	672	1,453	2,336	3,014	2,863	2,068
40-69%	-	570	1,265	1,900	2,464	3,063	1,853
15-39%	-	404	893	1,347	1,745	2,167	1,311
0-14%	-	-	-	-	-	-	-

Table 29. Summary of standing volume estimates for the simplified ecosystem diversity matrix (Mcft, 1000x cubic feet) on the Bitterroot Front Landscape

Size / Density	ns/nf	Seedl./ Sapl.	Pole	Medium	Large	Very Large	UEA	Total
70-100%	-	9,854	8,518	13,696	17,669	16,785	12,122	78,645
40-69%	-	16,716	22,254	33,416	43,345	116,731	103,183	335,644
15-39%	-	-	5,233	7,894	10,228	31,759	53,798	108,912
0-14%	-	-	-	-	-	-	-	-
Total	-	26,570	36,005	55,006	71,241	165,275	169,103	523,201

Discussion

Comparison and evaluation of alternative future condition scenarios

The management of the Bitterroot Front Landscape, as part of the larger Bitterroot National Forest, has to accommodate many different and often conflicting goals, dealing with recreation, wilderness, wild and scenic rivers, visual quality, cultural sites, research natural areas, fish and wildlife, range land, noxious weeds control, timber production, maintenance of soil productivity, water quality as well as quantity, minerals extraction, interagency land management, roads, utility corridors, protection, fire management, and economically efficient management (Bitterroot National Forest, 1987). This wide range of desired uses from the forest requires prioritization among goals that might not be of equal value and carefully balanced management of its resources. The three previously defined desired future conditions are compared among each other and with two no-action alternatives as well as the currently existing structural conditions to provide decision makers with a quantitative rather than a qualitative basis of comparison. Further considerations for the implementation of the alternatives on the ground like treatment scheduling, location, costs, restrictions, visual impacts and other factors are not incorporated.

The composition of structure types under the existing conditions in the year 2000 as well as for the alternative future conditions 120 years later is compiled in Appendix B.

The comparison utilized key factors to guide the design of the desired future condition alternatives namely, size class distribution, canopy cover, habitat characteristics for selected

wildlife species, and standing timber volume. Other factors could not be considered due to their complexity, i.e. cover types, disturbance processes and harvest volumes.

The existing conditions consist of mostly forested stands in the pole and large size classes (Figure 16). While both no-action alternatives would further increase the amount of area in the large size class, significant differences are apparent in the very large and seedling/sapling classes. Without any other management activities, fire suppression would favor the expansion of stands with very large mature trees at the expense of young regenerating stands (Figure 16). The existing conditions as well as the two no-action alternatives are described simply as even-aged structure classes since the inventory and the SIMPPLLE model do not recognize a managed uneven-aged structure. The "designed" desired future conditions include a proportion of managed uneven-aged structure (Figure 16), meaning that a certain proportion of every size class but seedling/sapling occurs in the even-aged as well as in the uneven-aged category.

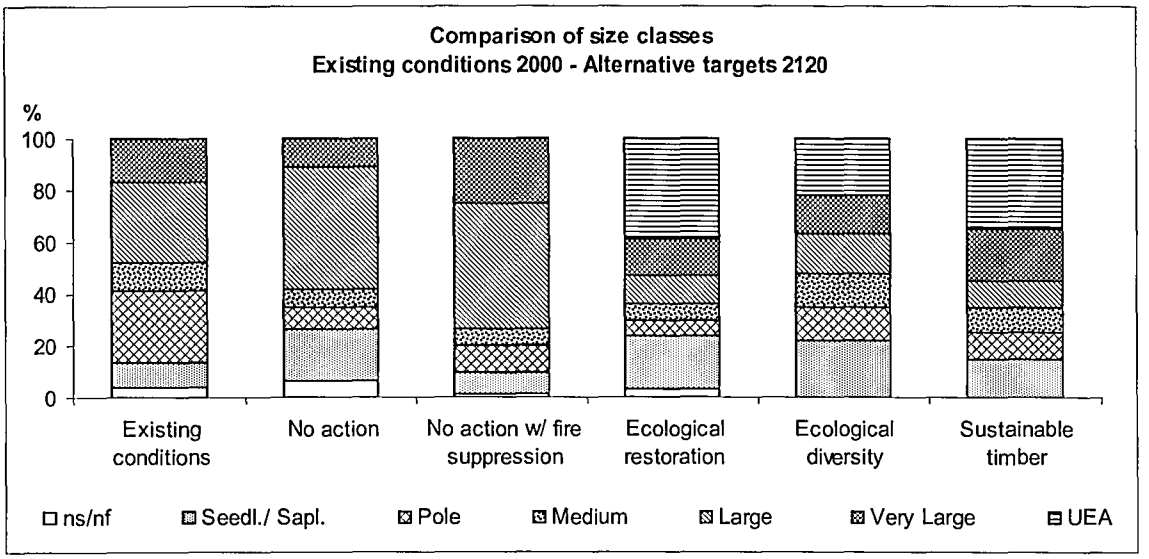

Figure 16. Stacked bar charts comparing size class distributions between existing conditions (2000) and five alternative scenarios (2120) within Bitterroot Front Landscape

All three designed future conditions feature a substantial amount of regenerating young stands. The ecological restoration alternative has the comparably largest amount of uneven-aged structure types but is less balanced in the proportion of stands in even-aged structure types.

The ecological diversity and sustainable timber production alternatives both provide more even amounts of all size classes, the former with a tendency towards an almost homogeneous distribution and the latter with a considerably higher percentage in the uneven-aged category.

Differences between the various future condition alternatives are more apparent in the density of canopy cover. Existing conditions (2000) have a large component in open (15-39%) stand conditions, which are considerably reduced in all the other alternatives (Figure 17), with the minimum occurring in the ecological restoration alternative. Both no-action alternatives have only a small component in moderate dense (40-69%) canopy cover conditions and the remaining component almost equally in either open or dense (70-100%) canopy cover conditions. In contrast the sustainable timber alternative has the majority of its stand area in the moderate size class and the smallest amount of dense canopy cover conditions of the designed alternatives. The ecological diversity alternative yields mostly open stands and comes closest to the currently existing conditions in terms of density (Figure 17).

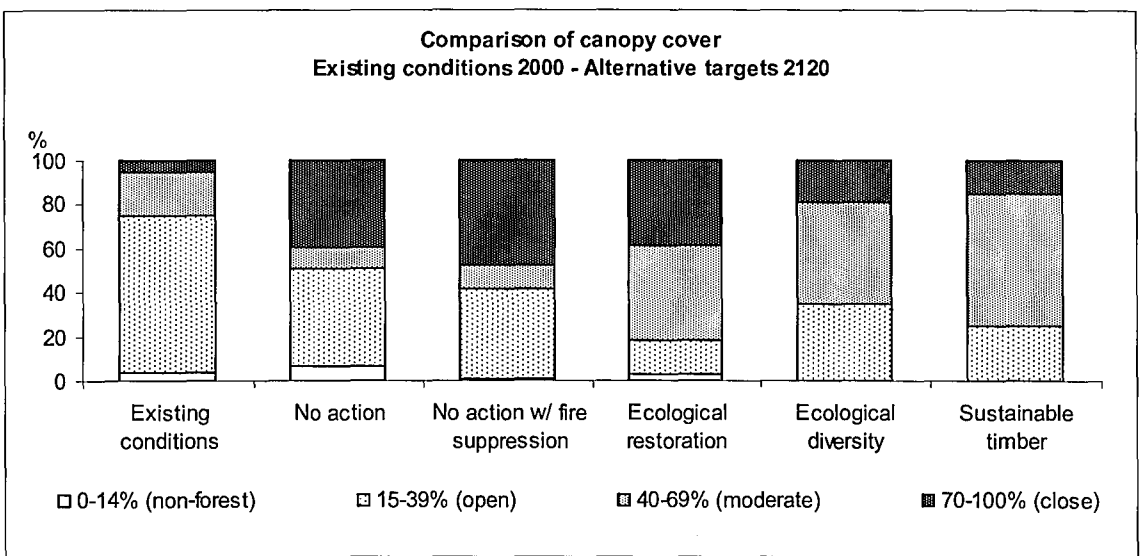

Figure 17. Stacked bar charts comparing canopy cover distributions between existing conditions (2000) and five alternative scenarios (2120) within Bitterroot Front Landscape

Comparison of the alternatives with respect to the availability of certain habitat characteristics for forest structure type-dependent selected wildlife species on the landscape shows considerable quantitative differences (Figure 18). Existing conditions consist of an overabundance of forage area and a minimum of hiding and thermal cover. The sustainable timber production alternative comes closest to the specifically designed ecological diversity alternative in terms of an appropriately distributed occurrence of habitat characteristics, although falling somewhat short of providing sufficient forage in favor of a slight overrepresentation of hiding and thermal cover. The no-action alternative with fire suppression as well as the ecological restoration alternative exhibits a similar and more or less homogeneous undesirable distribution of the three habitat characteristics (Figure 18). The higher amount of dense stands and fewer stands in moderately dense, medium and pole sized structure types shifts the habitat characteristics from forage to hiding and thermal cover. Without fire suppression, fires would create more open landscapes feasible for forage.

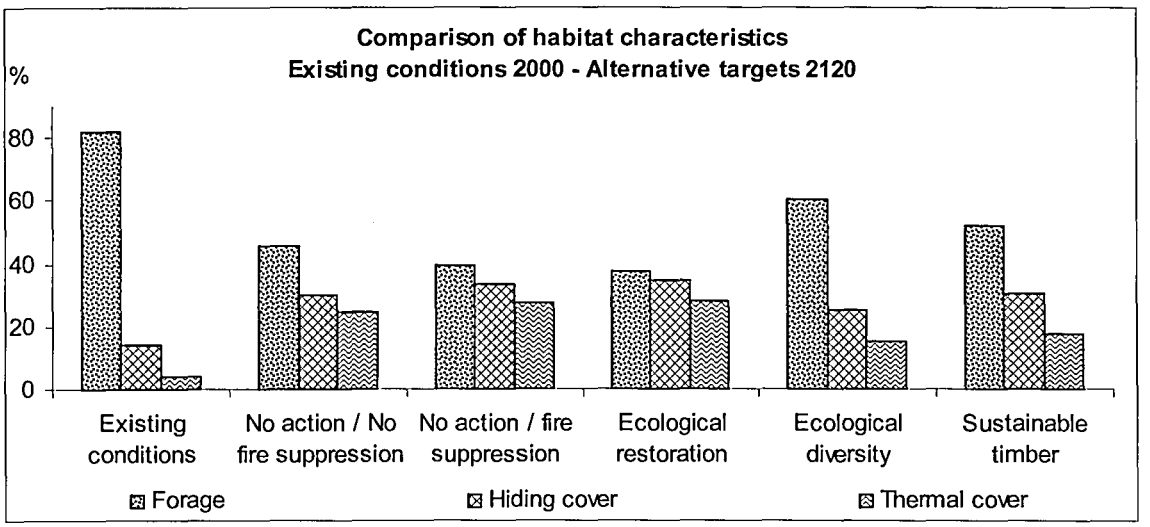

Figure 18. Comparison of habitat characteristics distribution between existing conditions (2000) and five alternative scenarios (2120) for the Bitterroot Front Landscape

A comparison of the alternatives with respect to standing timber volume estimates is displayed in Figure 19. The sustainable timber production alternative is designed to support a steady supply of merchantable timber across the planning period. Based on the yield potential of the existing habitat types and forest structure types and assuming optimum site conditions and health status of the standing trees as well as no natural disturbance events, a total standing volume of approximately 523 million cuft (3,138 million bdft) could be expected for the study area.

Thinning activities, pre-commercial and commercial, would be more extensive than for the other alternatives. Shelterwood cuts and selective cuttings would be scheduled for most of the stands to keep or establish moderate dense, and in particular uneven-aged, conditions where appropriate. At the end of the planning period a relatively large area would be in very large structure types to supply high valued timber, only surpassed by the no-action alternative with fire suppression (Figure 19). Both remaining alternatives, ecological restoration and ecological diversity result in a lower production of timber volume. While the ecological restoration alternative yields about the same volume as the sustainable timber production alternative, the ecological

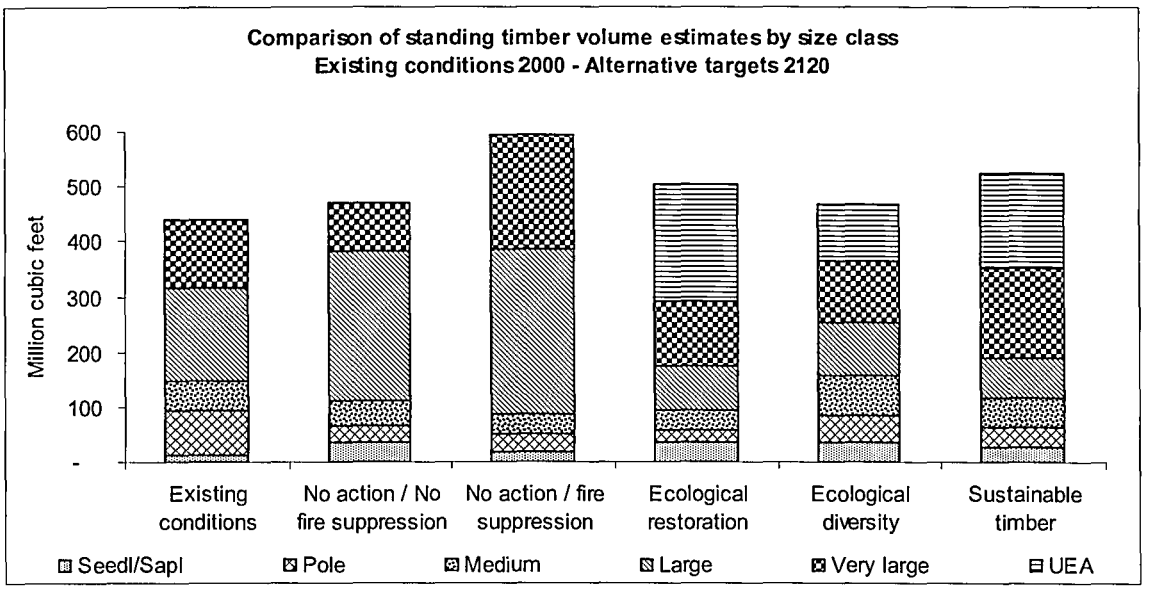

Figure 19. Comparison of standing timber volume distribution between existing conditions (2000) and five alternative scenarios (2120) for the Bitterroot Front Landscape

diversity alternative is estimated to produce about 55 million cuft less (330 million bdft) in standing volume.

Both no-action alternatives have their major volume in the large and very large size classes (Figure 19).

The previously described volume estimates are a rough estimate to provide a general comparison among alternatives. Further analysis of the timber inventory data utilizing currently available growth and yield models would provide better estimates of achievable timber harvest volumes.

The ecological restoration alternative yields the least desirable combination of habitat characteristics, with a considerable lack of forage areas and overabundance of cover. It provides, however, roughly the same potential timber volume as the sustainable timber production alternative combined with high structural heterogeneity.

The ecological diversity alternative might be least accomplished in terms of economic requirements, despite its close relation in terms of causality to the ecological restoration alternative. It yields the least standing timber due to its prevalence of open forest stands. Its utilities would probably lie in recreational opportunities, i.e. hunting, and in visually more appealing aspects.

The sustainable timber production alternative as designed accomplishes well a range of desired landscape properties with respect to timber yield and the proportion of preferred wildlife habitat characteristics as well as size class distribution. It is far off, however, from reestablishment of the canopy closures associated with historic conditions.

It is clear at this point that several alternative desired future conditions (DFC) are possible and each of them could be strongly defended or criticized by various interest groups. But rather than fight over a particular DFC, can common ground be found? (I.e. is there an alternative DFC

that would be generally acceptable to a large number of stakeholders?) Some compromise would be required, yet some of the DFC targets are quite similar, despite being developed from very different value perspectives. Rather than try to get agreement on one of the alternatives, can a new "preferred DFC" be considered or developed.

Integrated/ combined suggested desired future scenario

Forest ecosystem management requires the consideration of multiple goals, leading to multiobjective planning (Kangas & Pukkala, 1996). It strives to balance and relate to each other a set of three main objectives: Social needs, economic needs, and ecological capabilities (Kaufmann et al., 1994). Within this complex framework, concessions during the planning process and continuous adjustments during the implementation process are required. Future vegetation conditions will presumably not entirely match any single one of the above defined management targets due to the broad and often contentious range of society's values (Dewhurst & Kessler, 1999) as well as ecological processes and environmental changes. Rather than targeting a single-purpose management objective, the integrated desired future condition is more likely to be valid across a range of possible management objectives and future landscape conditions (Dewhurst & Kessler, 1999).

The integrated suggested desired future condition is carefully designed to achieve an approximation of as many of the previously established quantitative benchmarks rather than calculating the average of the three different structure type matrices as a comprehensive management target. While aiming at historic forest composition, structure and disturbance processes, it accommodates wildlife habitat considerations as well as the highest possible and sustainable timber supply. It is not spatially explicit since it considers the outcome for the forested part of the entire study area rather than assigning a specific management alternative to a specific subsection. However, it does not claim to be the single most desirable design since it compromises some aspects more than it does others. The main reason is that levels of a certain structure type combinations produce mutually conflicting results, e.g., the high amount of open

canopies required for forage availability in the ecological diversity category contradicts the relatively low amount for the ecological restoration alternative. Vice versa, the comparably high amount of high-value very large timber for the sustainable timber alternative and abundance of uneven aged stands for the ecological restoration and sustainable timber alternatives result in an overabundance of the related habitat features for the ecological diversity alternative.

Table 30 displays the structure type matrix for the integrated alternative desired future condition. At the end of the projection period, the size classes will be distributed as follows: seedling/ sapling 17%, pole 9%, medium 9%, large 10% and very large 15%. 39% are assigned uneven-aged management. About one third of the forested area (293,129 acres) namely 35% will have dense or closed canopies, 45% will have moderate dense canopies and 19% will have open canopies.

Size class / Density class	ns/nf	Seedl./ Sapl. 0"-5"	Pole 5"-9"	Medium 9"-15"	Large 15"-21"	Very Large >21"	UEA	Total density
70-100%	0%	6%	3%	3%	5%	5%	13%	35%
40-69%	0%	10%	5%	5%	4%	8%	13%	45%
15-39%	0%	1%	1%	1%	1%	2%	13%	19%
0-14%	1%	0%	0%	0%	0%	0%	0%	1%
Total size class	1%	17%	9%	9%	10%	15%	39%	100%

Table 30. Summary of Desired Future Conditions for the integrated alternative on the Bitterroot Front Landscape (Structure types)

A relatively large amount is assigned as uneven aged management to emulate the pattern and frequency of mixed severity fires and to diminish the divergence between the more uniform size class distributions of the ecological diversity and sustainable timber alternative compared to the skewed distribution of the ecological restoration (Figure 20). This allows for higher structural variation within stands and sustainable timber yield across the landscape while incorporating the lesser amounts of medium and pole size stands on the landscape as found in historical references and according to the prevalent fire regimes.

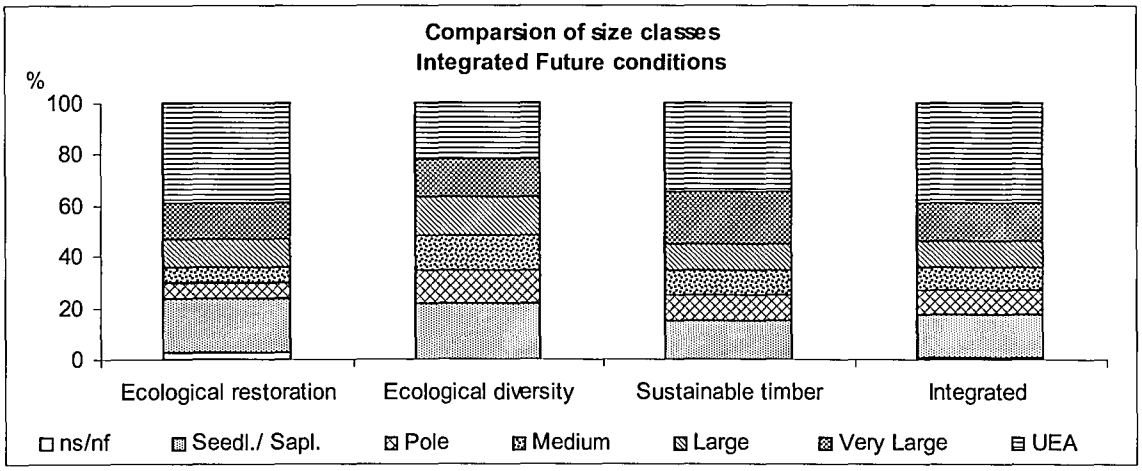

Figure 20. Stacked bar chart comparing the size class distribution for the Integrated Future Conditions on the Bitterroot Front Landscape

The canopy cover of the integrated alternative establishes middle ground between the ecological diversity and sustainable timber alternatives with a relatively high amount of open areas and less area in dense conditions, and the ecological restoration alternative with opposite features (Figure 21). This structure parameter is strongly correlated with the cover type, and particularly depending on the habitat type group as integration of biophysical conditions in combination with present fire regimes, and includes the spatial distribution of the various categories as well. E.g. while open conditions will occur mostly in the lower Ponderosa pine stands, dense conditions will be more typical for higher elevation types, like fir and Lodgepole pine types. The integrated alternative provides the majority of its area in the moderate dense category for improved annual yield increment while maintaining an adequate amount of open conditions reflecting stand replacing disturbance processes and necessary conditions for stand regeneration (Figure 21).

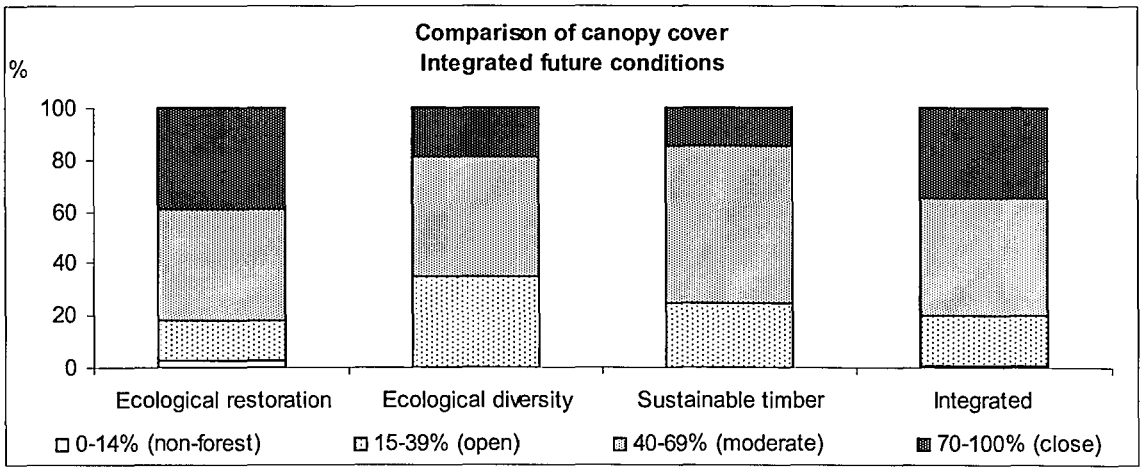

Figure 21. Stacked bar chart comparing the canopy cover class distribution for the Integrated Future Conditions on the Bitterroot Front Landscape

The concessions to achieve a suitable balance of diversity habitat characteristics were the most complex, due to the mutually exclusive effects of structural features as mentioned before. The attempt was to maintain the major proportions most suitable for selected wildlife species, while improving timber yield and resembling the historic structural compositions. The result is a disproportionate availability of hiding cover and reduced forage area for the forested part (Figure 22). However, on a landscape scale, forage habitat is made up for by about 15% of non-forested but vegetated area comprised of grasslands and shrublands at higher and lower elevations. Here, location, spatial and temporal combination as well as aggregation of certain structure types are crucial for the value of ecological diversity and to address wildlife habitat needs. Examples of criteria to consider are migratory behavior, i.e. spatially distinct summer and winter ranges, as well as preferences of various wildlife species related to successional and disturbance processes, e.g. senescent trees, forest openings and edge habitat.

In regard to standing timber volumes the integrated future condition matches the sustainable timber alternative very closely and exceeds any other alternative. With approximately 520 million cuft (3,120 million bdft) compared to 523 million cuft (3,138 million bdft) standing volume the most significant difference is the higher volume in uneven aged stands rather than very large even

aged stands (Figure 23). It combines the relatively uniform distribution of size classes for a sustainable high timber supply, the resilience of uneven-aged stands, and a considerable amount of very large timber. This increased quantity of volume in the very large size class should allow for reasonable harvest levels of high quality timber as well as the retention of patches of old trees to become senescent and snags.

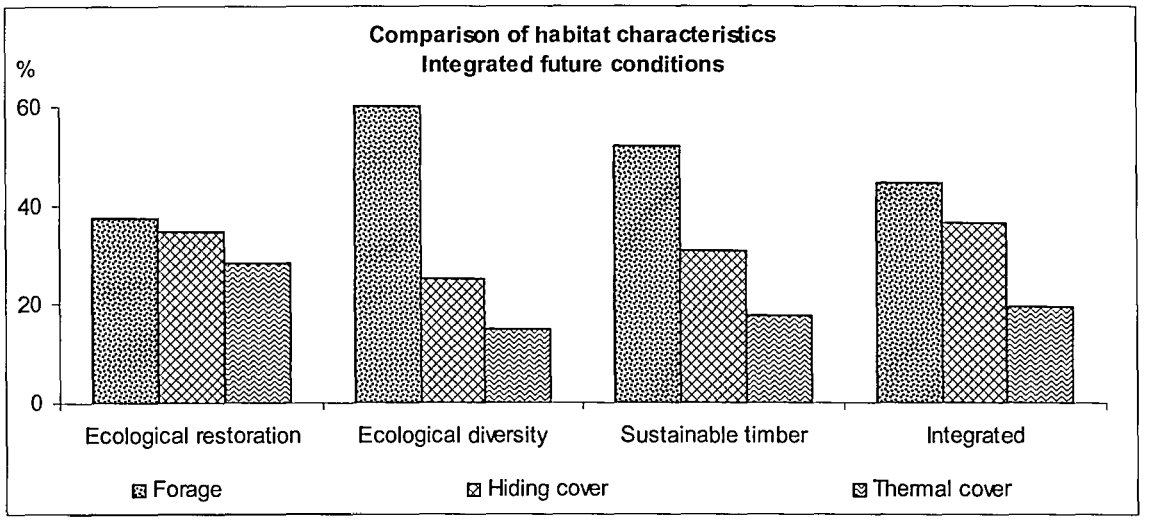

Figure 22. Grouped bar chart comparing the habitat characteristics distribution for the Integrated Future Conditions on the Bitterroot Front Landscape

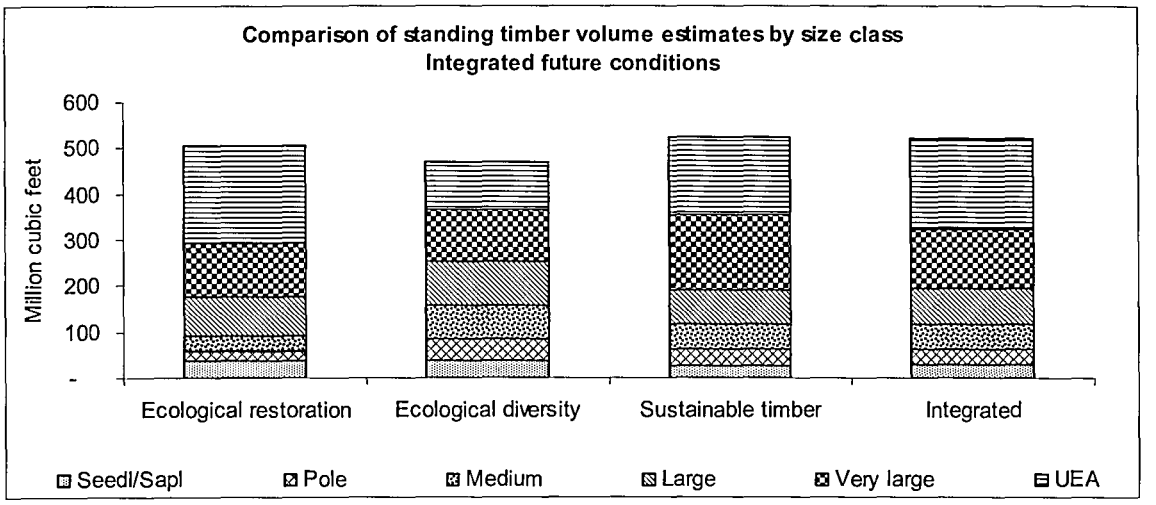

Figure 23. Stacked bar chart comparing the standing timber volume distribution for the Integrated Future Conditions on the Bitterroot Front Landscape

Although the integrated future condition falls short to meet all the quantitative requirements stated in the separate desired future condition goals, it provides a reasonable compromise.

The integrated alternative presented here is one example of an effort to find a "best practice" in consideration of previous single-goal alternatives. This was "manually" developed by one person seeking to achieve optimization among the previous alternatives. Typically, this is a team effort with a need to reach a consensus. The success of an integrated alternative is dependent upon the participants understanding of the compromises being made to achieve the consensus.

As mentioned earlier, the implementation of any management alternative must not be approached as a blanket solution for the entire study area. Instead, careful placement and arrangement of the various structure types is critical. It has to maximize benefits in regard to the overall designed future conditions benchmarks, while at the same time minimizing detrimental effects due to insufficient consideration of specific site conditions and complex ecological requirements. Adjustments will be necessary in individual sub-landscapes for a variety of opportunities and constraints. Nevertheless, it provides the context needed to operate at multiple scales.

Implementation considerations

"In the middle of difficulty lies opportunity."
Albert Einstein

The alternative desired future conditions were designed for an area encompassing more than 467,000 acres across an elevation range of almost 7000 feet, covering seven HUC 5 watersheds, managed in five fire management zones in four ownerships.

It is unlikely that the desired alternative can be implemented on the entire landscape. Rather implementation will need to be considered by sub-landscapes. Many different spatial extents are possible, most likely following natural delineations like watersheds, ridgeline, or valley bottoms.

The Bitterroot Landscape Assessment (Bitterroot National Forest, 1999) incorporates this idea by proposing management directions for the Bitterroot Front Landscape as well as 32 smaller subunits on the basis of sixth code watersheds.

Several unique restrictions and constraints apply to some sub-landscapes. In wilderness and roadless areas management activities are limited and expensive. On the other hand, designation of an area in fire management zone 1, the wildland/urban interface, often requires heavy management activities to establish less fire prone conditions. The USDA Forest Service can schedule and apply any silvicultural treatment in the roaded area to achieve proportions of desired structure types defined for a specific desired future condition. However, in the bigger picture and taking into account adjacent lands that might be either in private ownership or off limits for mechanized treatments, any treatment on actively "manageable land" has to be considered in such a way that "context is usually more important than content" (Forman, 1995). Hence it becomes crucial during the implementation process to consider surrounding areas, close by and further away, that might contribute to achieve a certain quantitative goal.

An example: The realization of a quantitative desired future condition as management policy is assigned to a 5th-code watershed. In the study area these watersheds reach from the Bitterroot River to the Montana-Idaho border along the crest of the mountain range. Ownership in the lower montane zone is mostly private, followed by USDA Forest Service land in consecutive zones of wildland/urban interface, roaded area, roadless area and finally wilderness (Map 4). Most likely private land owners will maintain their forest stands in fairly open to moderate dense conditions for optimum annual increment and to lower the risk of fires. The bordering wildland/urban interface on USDA Forest Service land would be in similar conditions, mainly for the latter reason. Beyond a narrow strip of roaded area, roadless area and designated wilderness prohibit heavy silvicultural treatments. Here, natural disturbance processes are the most common, but unpredictable and unreliable as agents of "active management". The forest manager now would have to incorporate these pre-set, but at the same time dynamic, conditions of structure types

and cover types and adjust for the deficient proportion. It becomes obvious that this might become a difficult task depending on the existing conditions. For example if an additional "supply" of medium-sized, dense Lodgepole pine is needed to balance the desired conditions and the area in question is recovering from a fire that occurred twenty years ago with trees in the seedling/sapling size class, then such a situation would take a long time to achieve. The options for the manager would be either to acknowledge that it may take several decades to achieve the DFC or to balance for shortage of conditions by seeing if adequate representation of those conditions is available in adjoining sub-landscapes.

Another example: After the desired target proportions are successfully established on a sub-landscape, a fire during the following fire season burns 10% of the area under consideration. Chances are that mixed fire severities might establish conditions in balance with the desired targets. Otherwise, the manager would have to attempt to readjust the proportions on the landscape through silvicultural treatments. Again, most likely, this might require switching spatial scales.

Implementing a desired future condition should be viewed as a process rather than a static state. It will require continuous adaptations to dynamic natural processes and needs to consider the cumulative outcomes of human management activities and natural disturbance processes. In the fashion of a steady-state shifting mosaic, the spatial configuration of structure type patches will change over time (Swanson et al., 1990). Understanding and incorporating the complexity and variety of spatial and temporal scales is crucial to address management issues on landscape scales (Loehle et al., 2002).

One of the initial objectives of this thesis was to display and simulate vegetation conditions at different spatial resolutions. The presentation of the results, however, is limited to the entire study area without addressing higher resolutions on sub-landscapes. The geodatabase contains data to display existing and generate potential future vegetation conditions and the GIS information provides the location of initial vegetation conditions and the management constraints imposed by

forest management zones, i.e. roaded, unroaded and designated wilderness areas, wildland/urban interface, as well as ownership. Thus it provides a warehouse of the necessary information to anticipate some of the problems that managers might face during the implementation process. Moving from theoretical to practical application, the database and analyses provided in this study could serve as an input to the spatial decision support system MAGIS (Multi-Resource Analysis and Geographic Information System) (Zuuring et al., 1995) as a logical next step for analysis of selected portions of the study area landscape. With MAGIS, management objectives and constraints could be considered and ecological and social information as well as scheduling management practices spatially and temporally integrated (Zuuring et al., 2004) and simulating the actual implementation of a DFC.

Other issues around the implementation of a DFC could be addressed with MAGIS in combination with SIMPPLLE: The state of vegetation conditions and location on the landscape under different management scenarios over time. The current analysis displays the initial vegetation conditions and potential future vegetation conditions in 120 years and hence how far the two conditions are apart from each other, and the development over time assuming no management action. But how long would it actually take to achieve the management target of a DFC? Would it come closer and faster to a DFC with no management? Could active management achieve a DFC quicker? What kind of silvicultural treatments would be necessary where and when? A simulation with the quantitative targets of various future conditions could display the different states of vegetation conditions for each decade while moving toward the management objective and thus guiding necessary management actions or no-actions.

Uncertainty in decision-making and adaptive management

"Better roughly right than exactly wrong."
Norman Meyers

Forest management on public lands is increasingly understood and perceived in the context of ecosystem-level thinking by scientists, policy makers, forest managers, and the public (Meffe et

al., 2002). But with increasing and more detailed knowledge, higher temporal and spatial resolution of available information along with larger spatial and temporal extent, collaboration across agencies and ownerships, higher integration of system knowledge and model sophistication, decision making processes in natural resource management become more complex and less comprehensible (Kangas & Kangas, 2004). Ironically on the other hand, ecological systems will probably never be understood in their entire complexity and hence the ecological effects of management actions and the efficacy of measures to regulate or enhance them can not be predicted (Walters & Holling, 1990). Contentious models and predictions regarding climate change and its effects on ecosystems in general and vegetation in particular further complicate or render it impossible to anticipate potential future conditions with certainty (Clark et al. 2001). Nevertheless, general expectations towards the accuracy of modeling results, predictability of natural disturbance events, validity of data and propositions, and appropriateness of management activities are increasing.

This leaves decision makers and natural resource managers little room for what could be viewed as errors in foreseeing and reacting to changes of societal goals (e.g. from utilitarian to conservation, preservation or vice versa), ecological processes (e.g. large scale forest fires, climate change), economic parameters (e.g. timber demand and pricing), and administrative actions (e.g. habitat protection for endangered species).

The combination of these factors makes uncertainty an important issue in the process of decision making in forest management (Kangas & Kangas, 2004), especially the prediction of effects of forest management activities due to lack of information on the probabilities of outcomes (Bormann & Kiester, 2004). It requires admitting, incorporating, embracing uncertainty and risk in the planning and implementation procedure of natural resource management decision making.

More often than not in forest management possible synergistic or cumulative effects of disturbance types are often ignored and would require the evaluation of interaction between natural disturbance effects and management regimes (Fall et al., 2004).

The result of the presence of uncertainty is often no-action – with its own set of consequences – instead of acknowledging risk and uncertainty and "using them as mechanisms for generating new understandings" (Bormann & Kiester, 2004).

Adaptive management, a concept developed since the early 1970's, is a systematic and cyclic process (Figure 24) for the evaluation of the effects of management practices and improvement of management policies (Canadian Ministry of Forests, 2001a). Its rationale is founded in some basic ideas as summarized by Bailey (2001): "(1) Natural resources are so complex that we cannot predict how a local population or area will respond to application of our theories. (2) Public uses of natural resources are controversial and we cannot predict how the public will respond to our management methods or results. (3) Therefore, at least some management should be designed as experiments, using the methods of science, so that we may obtain reliable knowledge of what does, or does not, work and of how the public responds to the results. (4) With resulting reliable knowledge, the next round of management can be adjusted to be more effective and more efficient."

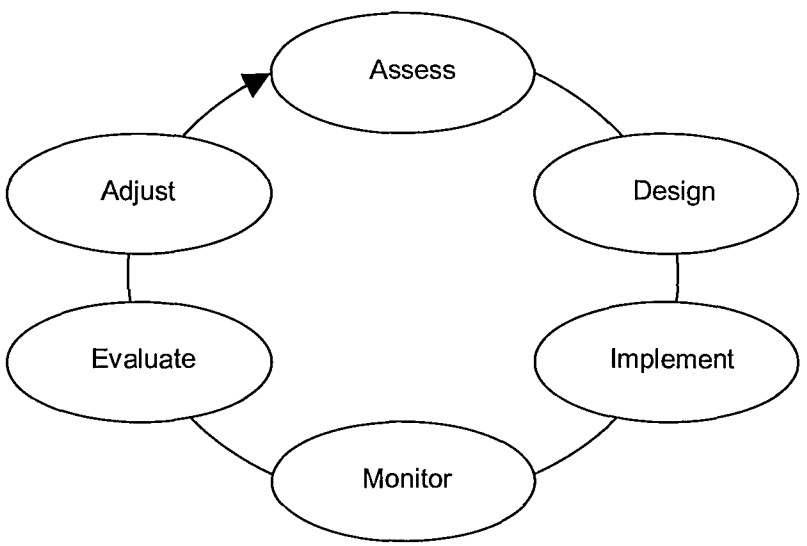

Figure 24. Diagram of an adaptive management process as six-step cycle (from: Canadian Ministry of Forests, 2001a)

Designed as an experimental management program (Walters & Holling, 1990), it combines the advantages of two ways of learning: the site- and learner-specific trial-and-error with the objective, transferable and replicable scientific learning (Meffe et al., 2002). Its key components are "learning by doing" and experimenting with complex systems (Walters, 1997) to learn from them.

In natural resource management it provides for continued reconsideration of management targets through adaptation to shifting environmental parameters, increasing knowledge, technological advances, societal changes, and economic factors. It is learning through observation during the implementation of a management plan that allows for immediate integration of new information into the management process.

However, the concept of adaptive management only works if all the stages are followed through and managers complete all six steps (Canadian Ministry of Forests, 2001a). Bailey (2001) sees major shortcomings in monitoring that never occurs or is conducted without pre-designated controls. Further, the large-scale management of experiments can only be useful, generate new knowledge and reduce knowable kinds of uncertainty, if they are carefully designed (Walters, 1997).

Bormann & Kiester (2004) expand the concept of adaptive management and introduce the options forestry model. They suggest embracing uncertainty by admitting it and as a consequence to diversify practices and policies across a large landscape, accelerate learning and eventually implementation, and to break up the traditional separation of scientists and managers. By applying multiple management alternatives simultaneously several goals can be achieved. Increased diversity of policies and management practices reduces the risk of total failure and likely results in partial success and failure. Further, considering public participation and appreciation of management activities in the decision making process, a higher diversification of policies and practices will allow more interest groups and stakeholders to see their goals represented in the planning area. At the same time, the speed of learning is increased through

replicated experiments and comparison of a higher number of policies at the same time. According to Bormann & Kiester (2004) this learning strategy can only be successful if the agency or institution conducting the experiment is able to adapt to new information in a reasonably short time so as to enter into the next iteration of experimental setup and monitoring. For an existing organization this requires the fusion of the learning research branch and the doing management branch to enhance communication and increase permeability of information.

The implementation of the quantitative desired future conditions for the Bitterroot Front could follow this approach. A distribution of the various target proportions of structure types and management practices over the entire landscape of the study area, a scientifically sound set of testable evaluation parameters and close cooperation and interaction between scientists and specialists in the managing agency could provide the means for a successful and publicly accepted management plan.

Summary and Conclusions

This study assesses the landscape of the Bitterroot Front and provides an overview of existing vegetation conditions as well as valuable information to managers by developing feasible quantitative desired future conditions. Its main purpose is to provide an overview of current landscape features and to propose planning and management targets in an ecosystem management context. Further, it demonstrates a concept for an efficient landscape assessment process for a large landscape as a foundation for future ecosystem management planning and implementation. Framed by management guidelines, it addresses a range of issues on a landscape-scale to encourage landscape-level thinking with its spatial and temporal dimensions rather than common stand-level thinking.

With these data and a variety of potential scenarios available, managers, the public and other decision-makers have crucial information on hand to move toward agreement on

management actions. The alternative future scenarios were explicitly designed to provide quantitative targets, rather than standard qualitative statements, as guidelines for management planning. With numerous factors to be considered to meet the goals stated in the Forest Plan for the Bitterroot National Forest, comparative quantification and synoptic visualization of management actions – or no-actions – are intended to facilitate communication during the decision-making process.

By providing a conceptual framework in combination with a necessary geodatabase and landscape-scale analysis, this study aims to facilitate consensus among the diverse values and goals of stakeholders in today's public land management. Relationships between existing vegetation conditions and desired future conditions are quantified in order to enable a shared understanding of the consequences of alternative management strategies. It visually demonstrates the quantitative differences and similarities among competing ideas and identifies common ground in decision making for how to manage forest landscapes, particularly on public lands.

Finally, forest management and planning processes need monitoring and evaluation of the forest ecosystem as it progresses towards the desired future conditions. The management decisions need to be validated and if necessary adapted. An adaptive management approach would allow for "learning by doing" and increase flexibility to respond to changes in environmental and societal parameters.

The majority of the initially stated objectives of this thesis were accomplished. Existing vegetation conditions were summarized and displayed as a key starting point and benchmark for planning, although not at different spatial resolutions, i.e. sub-landscapes. Four primary alternative future management scenarios were developed and the outcomes compared, including the design of an integrated future scenario. To deploy the full utility of the study and to move from theoretical to practical application as well as to illustrate the various states of the landscape over

time, the simulation of the designed alternatives need to be completed with use of the MAGIS model and additional SIMPPLLE projections.

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Personal communication

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Glossary

- Beta diversity: The change in species diversity between ecosystems. Beta diversity allows for comparison of diversity between ecosystems.
- Chorology: The study of the causal relations between geographical phenomena occurring within a particular region.
- Cross-walk: The correlation of class labels between two classification systems.
- Lock-in processes: Scheduling of disturbance processes, e.g. existing insect infestations. Disturbance processes can be scheduled ("locked-in") for a specified time step, the default being "no disturbance process".
- Cumulative effects: Changes to the environment that are caused by an action in combination with other past, present, and future human actions.

Appendices

Appendix A

Pathway and System Knowledge Files	Content
bttr-a1-012004.pathway bttr-a2-012004.pathway bttr-b1-012004.pathway bttr-b2-012004.pathway bttr-b3-012004.pathway bttr-c1-012204.pathway bttr-c2-012404.pathway bttr-c3-012404.pathway bttr-d1-012504.pathway bttr-d2-012004.pathway bttr-d3-012404.pathway bttr-e1-012404.pathway bttr-e2-012504.pathway bttr-f1-012404.pathway bttr-f2-012504.pathway bttr-g1-012004.pathway bttr-g2-012004.pathway	*All possible vegetation states (comprised of cover type, size class, density class, layering, habitat type, climax species, seral species, processes) for a given habitat type group (e.g habitat type group "a1" in bttr-**a1**-012004.pathway). Each file contains information, on how long a stand spends within a size-class, how density changes over time, how long it takes for tolerant species to fill in, how long seral species stay in a mixture, the influence of density on time within a state, and the influence of the habitat type.*
new-bttr.firespread	*Logic to determine how a fire will spread to the neighboring plant communities. Spread can vary by type of fire (light, mixed severity, stand replacing), relative spatial position, the vertical structure/density of the stand, fire resistance of the plant community, and past processes.*
new-bttr.firetype	*Logic for the determination of how a fire develops from a fire event. Development can vary by weather conditions (drier, average, wetter), the structure/density of the stand, fire resistance of the plant community, as well as past treatments or processes.*
wbttr-by-zones.fmz	*Probability of a fire event by fire size and suppression costs depending on fire management zone (if defined for the landscape). Probability can vary by weather conditions as well as size/structure of the stand, the ownership and road status.*
lockin-processes.process	*Scheduling of disturbance processes at the beginning of the simulation.*
bttr-rootdisease.probability	*Probability of root disease depending on habitat type group, cover type and past treatment.*

(Chew et al., 2002)

Appendix B

Percent distribution of existing (2000) and alternative future stand condition targets (2120) within Bitterroot Front Landscape. *(NS = non-stocked, SS = Seedling/Sapling, UEA = Uneven-aged management).*

Existing conditions 2000

Size class		<5"	5"-9"	9"-15"	15"-21"	>21"		
Canopy cover	NS	SS	Pole	Medium	Large	V. Large	UEA	Total
70-100%	0%	0%	2%	1%	1%	1%	0%	5%
40-69%	0%	1%	6%	5%	3%	6%	0%	20%
15-39%	0%	9%	19%	6%	27%	10%	0%	71%
0-14%	4%	0%	0%	0%	0%	0%	0%	4%
Total	4%	10%	27%	11%	31%	17%	0%	

No action alternative w/o fire suppression 2120

Size class								
Canopy cover	NS	SS	Pole	Medium	Large	V. Large	UEA	Total
70-100%	0%	19%	5%	3%	5%	8%	0%	40%
40-69%	0%	0%	1%	2%	6%	1%	0%	10%
15-39%	0%	0%	2%	3%	36%	2%	0%	44%
0-14%	7%	0%	0%	0%	0%	0%	0%	7%
Total	7%	20%	8%	7%	47%	11%	0%	

No action alternative w/ fire suppression 2120

Size class								
Canopy cover	NS	SS	Pole	Medium	Large	V. Large	UEA	Total
70-100%	0%	8%	4%	2%	9%	23%	0%	47%
40-69%	0%	0%	0%	1%	9%	1%	0%	11%
15-39%	0%	0%	6%	3%	30%	2%	0%	40%
0-14%	1%	0%	0%	0%	0%	0%	0%	1%
Total	1%	8%	10%	6%	49%	25%	0%	

Appendix B (ct'd)

Ecological restoration alternative 2120

Size class / Canopy cover	NS	SS	Pole	Medium	Large	V. Large	UEA	Total
70-100%	0%	9%	2%	2%	5%	6%	15%	39%
40-69%	0%	9%	3%	3%	4%	6%	18%	43%
15-39%	0%	3%	1%	1%	2%	2%	6%	15%
0-14%	3%	0%	0%	0%	0%	0%	0%	3%
Total	3%	21%	6%	6%	11%	14%	39%	

Ecological diversity alternative 2120

Size class / Canopy cover	NS	SS	Pole	Medium	Large	V. Large	UEA	Total
70-100%	0%	2%	3%	3%	3%	3%	5%	19%
40-69%	0%	17%	8%	8%	4%	4%	5%	46%
15-39%	0%	3%	2%	2%	8%	8%	12%	35%
0-14%	0%	0%	0%	0%	0%	0%	0%	0%
Total	0%	22%	13%	13%	15%	15%	22%	

Sustainable timber alternative 2120

Size class / Canopy cover	NS	SS	Pole	Medium	Large	V. Large	UEA	Total
70-100%	0%	5%	2%	2%	2%	2%	2%	15%
40-69%	0%	10%	6%	6%	6%	13%	19%	60%
15-39%	0%	0%	2%	2%	2%	5%	14%	25%
0-14%	0%	0%	0%	0%	0%	0%	0%	0%
Total	0%	15%	10%	10%	10%	20%	35%	

Appendix B -- Simulation of fire-related disturbance processes with SIMPPLLE and comparison with historic fire data from the Bitterroot Forest.

*(*RJVA Task D.1.b. -- *Predict how the vegetation on this area will likely change over time for the "No Action" scenario both with and without fire suppression utilizing the SIMPPLLE model. Compare the wildland acres burned in these "No Action" simulations with data from the wildland fires experienced in recent past decades, including acres burned by fire intensity classes and fire-size distribution).*

Data.

- SIMPPLLE (v2.2) runs, 12 cycles @ 10 years @ 30 runs, with and without fire suppression.
- Historic fire data for the BNF provided by Jim Fears, RO Hamilton, May 03 2004.

Analysis.

Data from fire-related disturbance processes in SIMPPLLE were summarized and compared with historic fire data from the Bitterroot National Forest.

The historic fire data layer from the Bitterroot National Forest was clipped in ARCGIS based on spatial relevance for the Bitterroot Front. Burned acres and number of fires were summarized by decades 1880 through 2000 (Table 1).

Table 1. Historic fire data layer for the Bitterroot Front Area

	Decade	Acres	Count
BNF wildfire data	1880	11,391	9
	1890	6,651	11
	1900	3,378	9
	1910	33,305	61
	1920	7,658	21
	1930	7,548	7
	1940	794	6
	1950	0	0
	1960	0	0
	1970	2,377	1
	1980	25,659	44
	1990	1,472	4
	2000	12,439	4
Average		**8,667**	**14**

To facilitate comparison between historic and simulated data, the historic data was broken down into fire size classes used by SIMPPLLE (0-0.25, 0.26-9, 10-99, 100-299, 300-999, 1000+ [acres]) and aggregated for number of fires and acres burned by fire size class (Figure 1 and Figure 2).

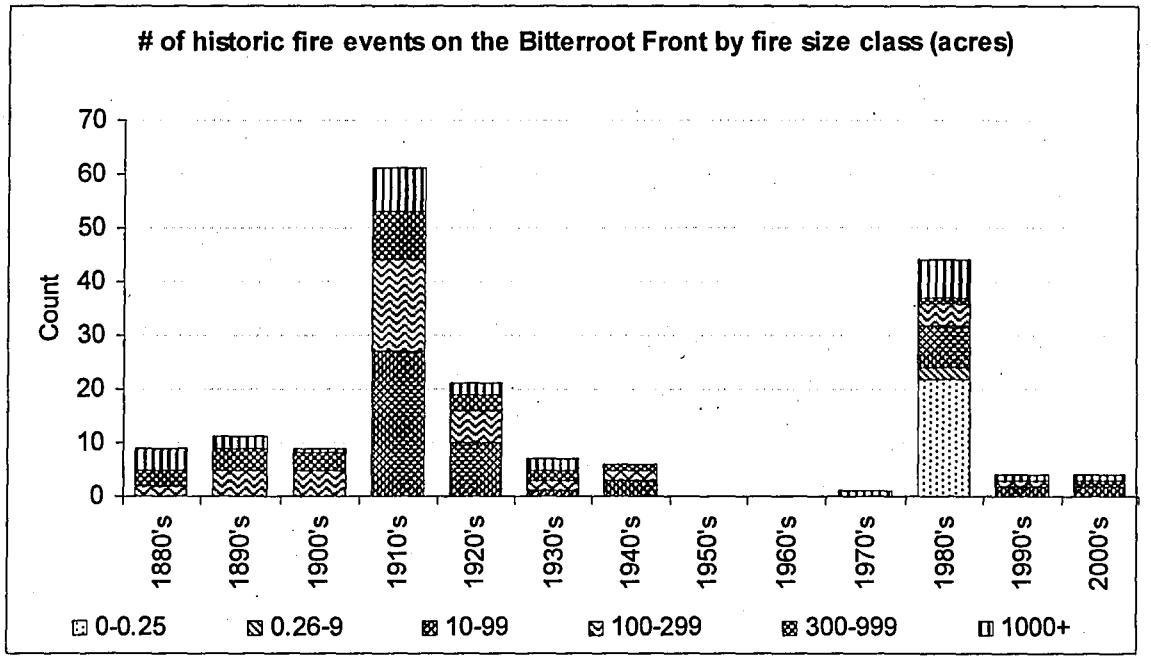


Figure 1: Number of historic fire events on the Bitterroot Front by fire size class (acres).

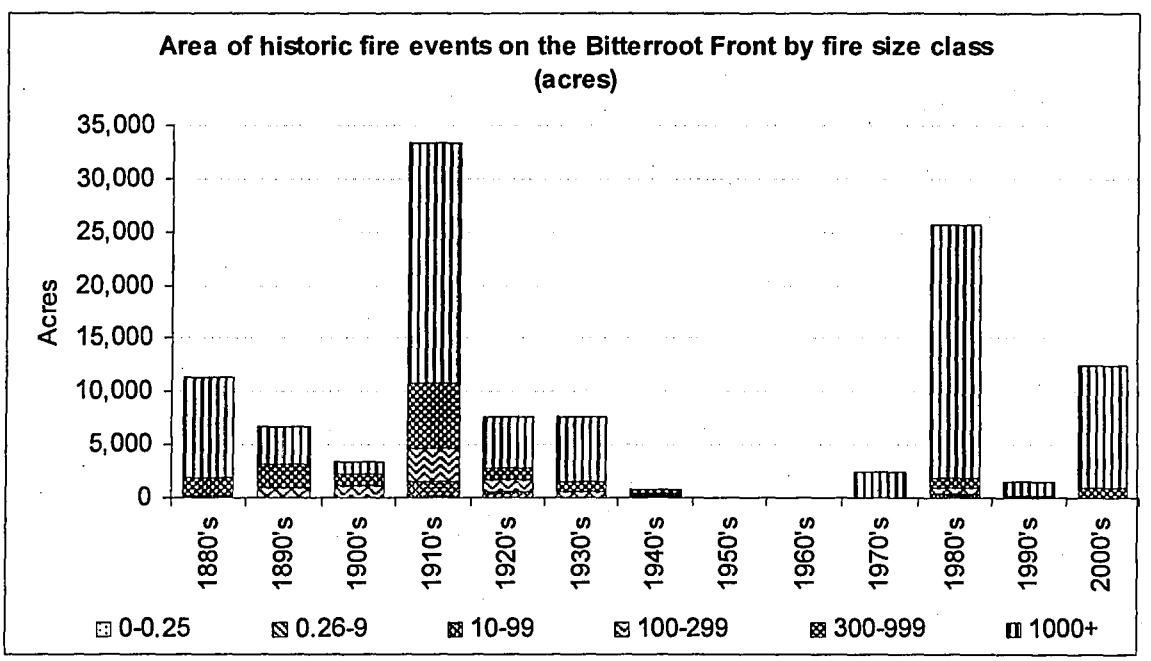


Figure 2: Area of historic fire events on the Bitterroot Front by fire size class (acres).

Simulated fire related disturbance data from SIMPPLLE was summarized for fire suppression /no fire suppression, and analyzed for total acres burned and acres burned by

mixed severity and stand replacing fires. Burned acres and number of fires were summarized by projected decades from 2000 through 2110(Table 2).

Table 2: Simulated acres and number of fires (mixed severity and stand replacement combined) for the Bitterroot Front Area from SIMPPLLE simulations.

		w/ fire suppression			w/o fire suppression		
	Decade	Acres (all)	Acres (m+s)	Count	Acres (all)	Acres (m+s)	Count
SIMPPLLE simulation	2000	16,797	11,672	344	114,460	78,370	299
	2010	21,911	12,840	323	132,676	74,699	359
	2020	15,207	9,817	291	137,021	69,256	334
	2030	20,281	12,592	325	151,837	73,117	326
	2040	17,765	11,693	349	138,041	58,503	310
	2050	19,362	12,808	349	149,653	70,657	324
	2060	20,615	13,817	313	147,355	61,084	327
	2070	21,430	12,046	309	151,677	71,984	331
	2080	23,973	16,702	345	129,107	52,952	324
	2090	22,687	14,391	323	151,551	66,597	357
	2100	20,796	13,211	317	171,818	75,125	329
	2110	31,858	21,941	336	143,052	53,714	344
Averages		**21,057**	**13,628**	**327**	**143,187**	**67,172**	**330**

m+s: mixed severity and stand replacing fires

SIMPPLLE simulation data was also summarized according to fire size classes by number of fires and acres burned for the **"No Action w/fire suppression"** alternative (Figure 3 and 4).

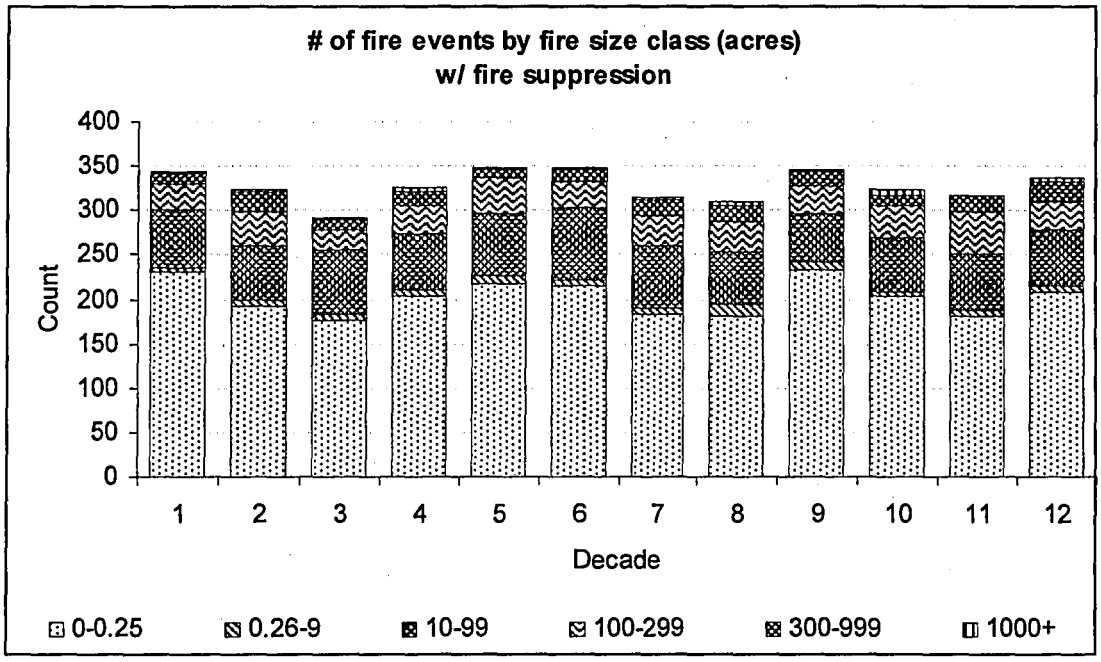


Figure 3: Number of fire events by fire size class (acres) from SIMPPLLE simulation w/ fire suppression.

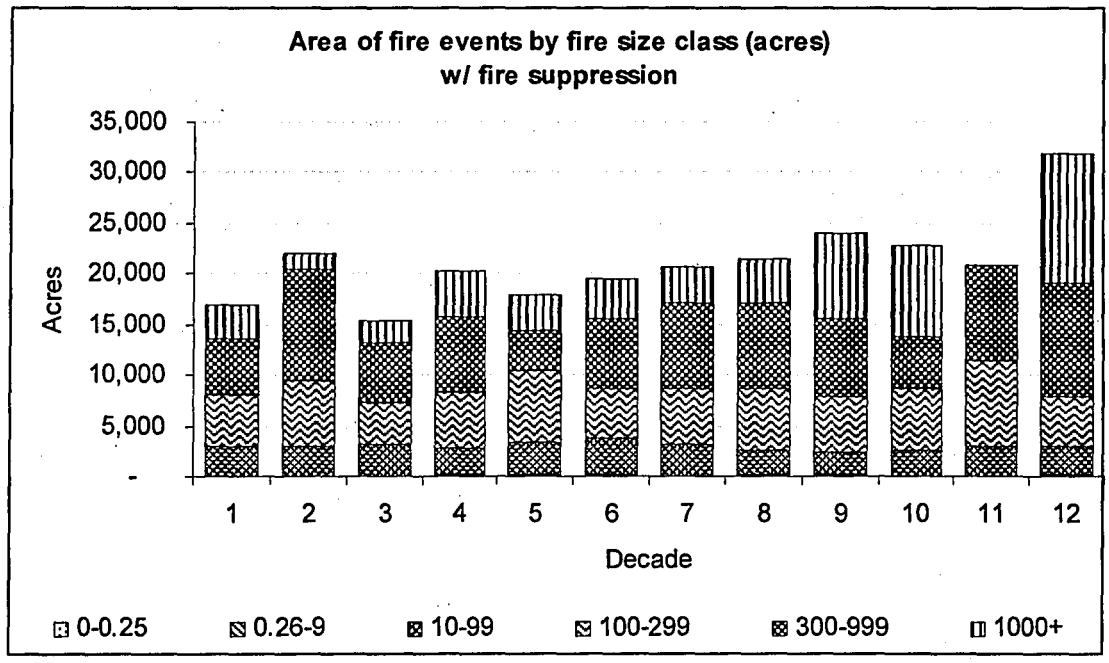


Figure 4: Area of fire events by fire size class (acres) for SIMPLLE simulation w/fire suppression.

SIMPPLLE simulation data was also summarized according to fire size classes by number of fires and acres burned for the **"No Action w/o fire suppression"** alternative (Figures 5 and 6).

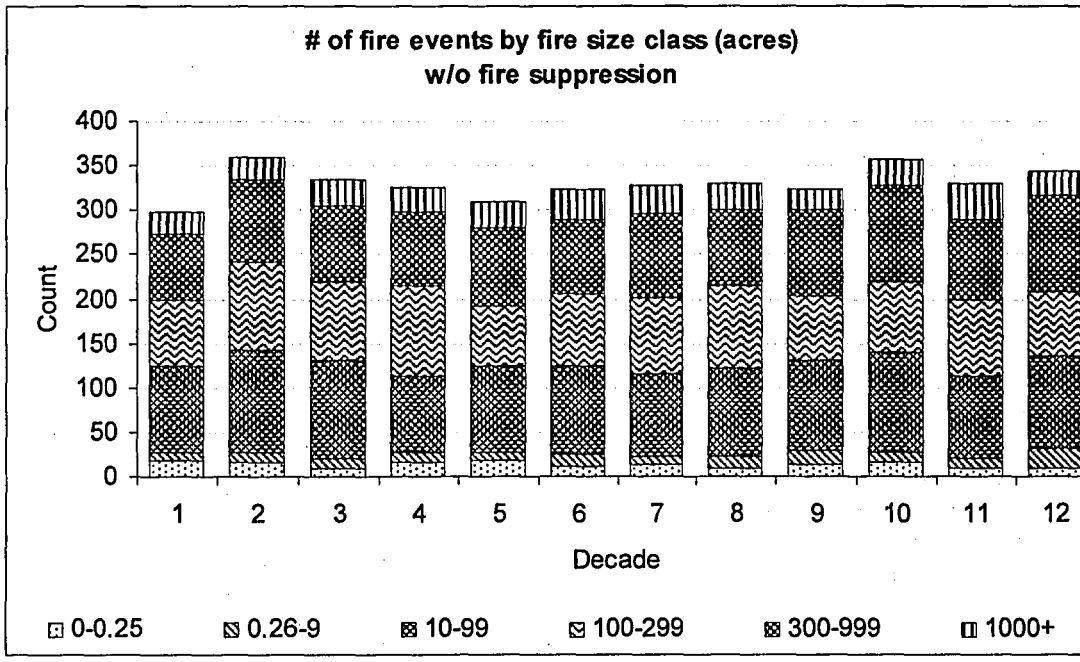


Figure 5: Number of fire events by fire size class (acres) for SIMPLLE simulation

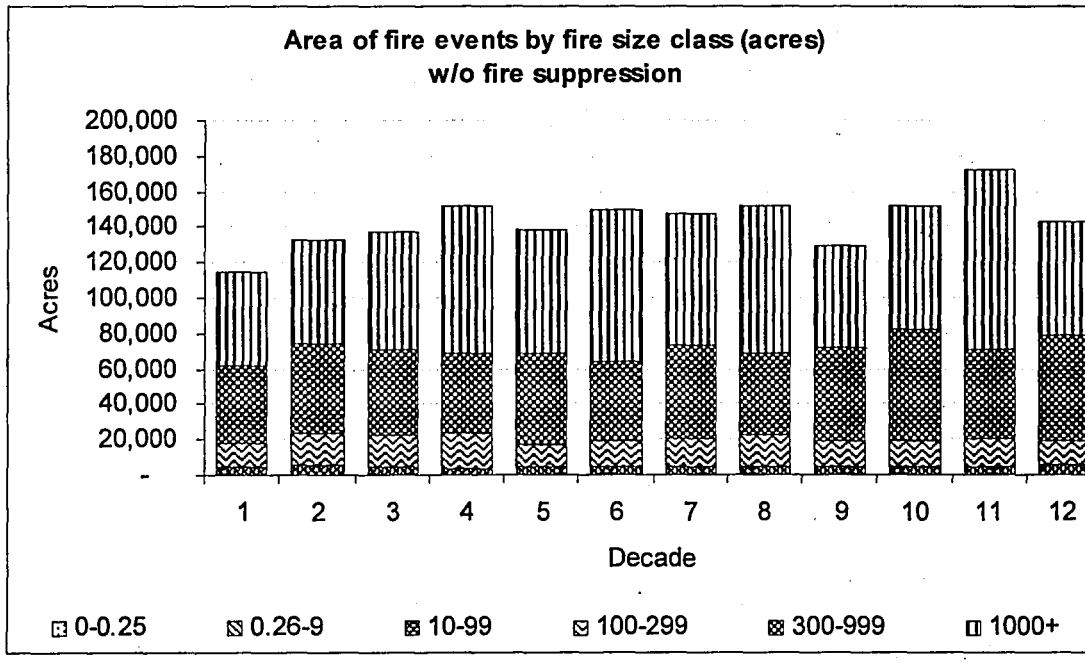


Figure 6: Area of fire events by fire size class (acres) for SIMPLLE simulation

Interpretation of Bitterroot Front historic fire data (Table 1 and Figures 1 and 2).

1) The historic data reflects the general trend of high fire acreage in the late 1800's through the 1930's, low acreage burned in the 1940's through 1960's, and the higher acreage burned in the last four decades (Agee 1993, Arno and Allison-Bunnell 2002, and Bonnickson 2000).

2) The historic data also reflects that fire suppression may have become increasingly effective in reducing the acreage burned in all fire classes less than 1,000 acres. On the other hand, acreage of large fires during the last four decades is similar to the 1890 through 1930 decades. This supports the general viewpoint that stand conditions of later decades represent increasingly high fire hazards and resistance to control measures.

Interpretation of SIMPPLLE simulations (Table 2 and Figures 3 – 6).

1) The number of fires for the "NA w/ fire suppression" scenario range from 291 to 341 (average 327) while fire acres range from 15207 to 31858 (average 21,057) (Table 2, Figures 3-4).

2) For the "NA w/o fire suppression" alternative, the number of fires range from 299 to 359 (average 330) while fire acres range from 114,460 to 143,052 (average 143,187) (Table 2, Figures 5-6).

3) The number of fires is similar in the two alternatives (327 vs. 330 averages) with no obvious trends relative to decades (Table 2 and Figures 3 and 5).

4) The acres burned "NA w/o fire suppression" are generally +/- 7 times higher than acres burned with "NA w/ fire suppression" (Table 2) with no obvious trends by decades (Figures 4 and 6).

5) The distribution of number of fires and fire acreages by fires size classes is relatively constant through the decades for both scenarios (Fig 3-6). (Exception noted for decades 10-12 in Figure 4.)

Comparisons of Historic vs. SIMPPLLE (Figures 7-8 and Table 3)

A brief table (Table 3) provides some numbers for comparison purposes in addition to Figures 7 and 8.

Table 3. General comparison values for Historic fire data and SIMPPLLE output.

Item	Historic fire data	NA-w/fire supp.	NA-w/o fire supp.
a) Number of fires/decade	14	327	330
b) Total acres burned/decade	8,667	21,807	143,187
c) MS & SR acres burned/decade	?	13,544	67,172

Graphs of acres burned by historic fires and SIMPPLLE simulations of **"No-Action w/fire suppression"** are shown in Figures 7 and 8.

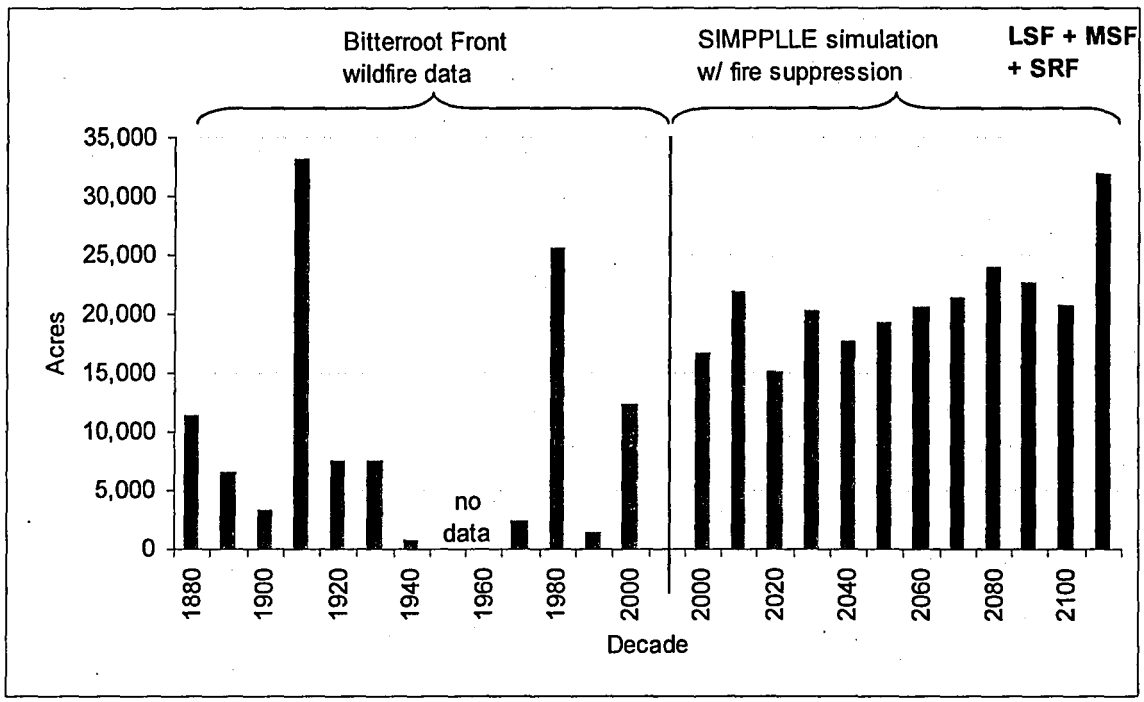


Figure 7: Historic acres burned vs. SIMPPLLE simulation w/ fire suppression for three classes of fires combined.

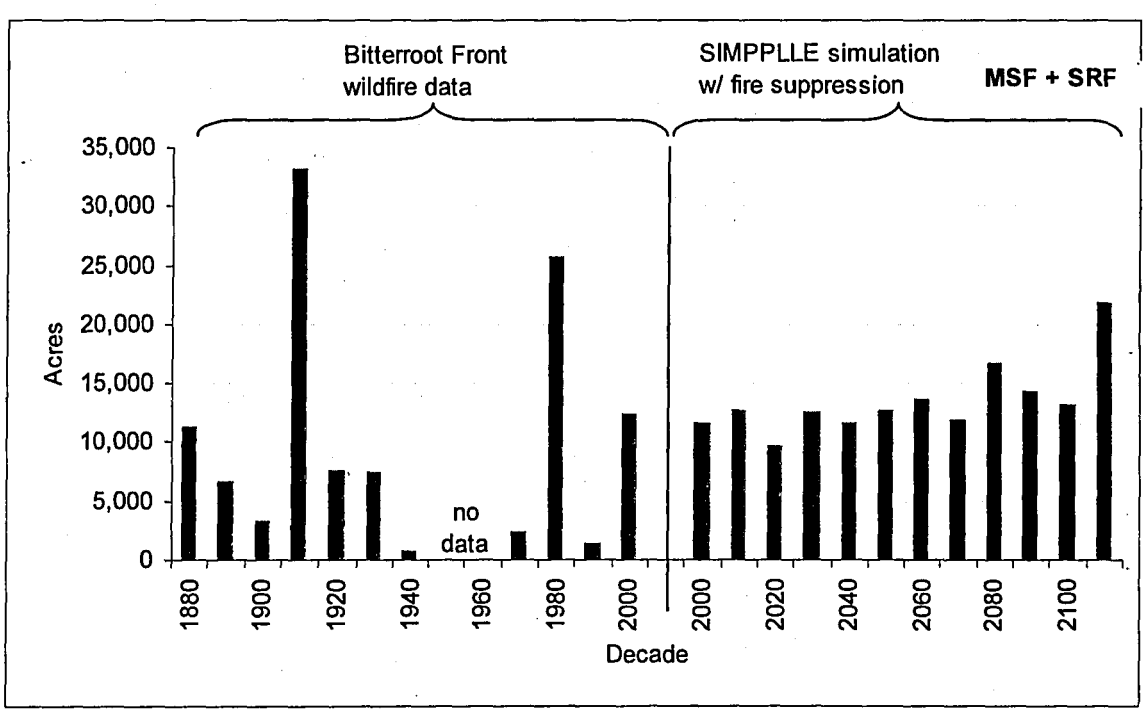


Figure 8: Historic acres burned vs. SIMPPLLE simulation w/ fire suppression for two classes of fires (Mixed Severity and Stand Replacement) combined.

1) Comparison shows much number of fires for SIMPPLLE than for Historic (Table 3). SIMPPLLE demonstrated more uniformity across decades than Historic (Figure 7).

2) Comparison shows much higher fire acreages in general for SIMPPLLE than for Historic (Table 3). SIMPPLLE demonstrated more uniformity across decades than Historic (Figure 8).

Discussion

1) If the Bitterroot fire history database includes acreage of all fires (including low severity underburns) then it suggests that SIMPPLLE predictions are too high.

2) The values for "NA w/o fire suppression" seem to be too high. The prediction of an average of 143,187 acres/decade for all fires and 67,172 acres/decade for MS and SR fires combined represents % of the Bitterroot Front landscape would burn each decade. One would expect that this amount of burning would eventually reduce fir hazards resulting in a decline in acreage burned in future decades. A question is raised if the feedback loops, or recognition of past events that change stand conditions is functioning properly within SIMPPLLE.

3) One must recognize that we are dealing with two different time periods (past vs. future) that likely had very different initial conditions. Literature strongly supports that initial condition historically were less prone to large, intense fires than stand conditions today. Therefore the historical record would be expected to show less acreage burned today than we might expect based on today's initial conditions, especially for the "NA w/o fire suppression" alternative.

Maps of SIMPPLLE Fire Simulations and Report to Bitterroot N. F. Managers

A special meeting of BEMRP researchers and managers was held in March 2004 to explore output of various models as information to help inform the Bitterroot National Forest in their Fuel Management programs. The written report from that meeting and maps that were generated by Martin Twer for a poster presentation are presented below.

Use of the SIMPPLLE Model for Planning of Fuel Treatment Priorities
Researcher and Manager Team Meeting 3-26-04

Jim Chew, Bob Pfister, Martin Twer

CONTEXT (Pfister)

The BEMRP Landscape Project Proposal provides an overview of our major collaborative effort for a five-year period. Phase One of this project is a collaborative effort to evaluate the utility of several models to inform decisions on: 1) the best strategy (logic) for designing implementation of fuel management treatments for the Bitterroot Front Landscape, and 2) to help inform selection of a representative smaller landscape to actually compare and demonstrate implementation of alternative fuel management treatments, timing, and spatial strategies. A study plan is being developed to guide efforts for Phases Two and Three.

SIMPPLLE is one of several models being evaluated by researchers and managers in a team effort. It is expected that interpretation of each model output(s) will offer unique insight for a variety of specific management planning questions. Our immediate concern is to provide SIMPPLLE output that will inform Phase One questions. The minutes from the February 19 Meeting reflect a broad-ranging discussion of possible items to address during the next five years. If we try to address all the Phase Two, Three, etc. questions at this time, we will not complete Phase one for five years! Therefore, our presentation for this meeting is focused on our interpretation of the following management questions:

1. What are the relative susceptibilities to stand-replacing and mixed-severity fire of every stand (polygon) in the Bitterroot Front landscape? (Relative risk of SR and MS fire of existing conditions to establish priorities for effective use of limited fuel management funds.)
2. Where in the BF landscape are these conditions located. (Map of "Risk" of SR & MS fire.)

The answers to these questions are derived by running SIMPPLLE on the BF Existing Conditions database with No-Action alternatives. (Note: The probable **effects** of any proposed treatments on future vegetation conditions and expected frequency of ecological processes can be determined by running SIMPPLLE again with the new vegetation conditions that would result from treatment of specified polygons. This provides a rapid "what if" analysis for any number of alternative treatment scenarios.)

SIMPPLLE has been used in numerous planning applications over the last decade to address a wide variety of landscapes, large and small. It has also been used to address a wide variety of management questions. Much of the background information is covered in the "Users Guide". The handling of fire in SIMPPLLE starts on p. 153 in the Users Guide (J:\fsfiles\ref\infocenter\ftp\pub\SIMPPLLE). We were asked to provide a "menu" of possible outputs to help illustrate choices available for different questions. Jim Chew will present a powerpoint presentation and handouts relative to this assignment.

SIMPPLLE OUTPUT MENU (Chew)

Powerpoint presentation and handout.

SELECTED SIMPLE OUTPUT for PHASE ONE QUESTIONS (Twer)

The latest run for SIMPPLLE (with previously identified updates) was run 30 times for the No-Action with Fire Suppression Alternative and 30 times for the No-Action without Fire Suppression Alternative. The model was run for 120 years in 10-year time steps. The average predictions of the 30 runs was summarized in Tables 1 & 2, and Figure 3 (Appendix B-2) which show percentage and acreage of the landscape affected in each time step and updates of the landscape vegetation conditions at the end of each period. Bar Graphs are presented to illustrate distribution of stands by size class over time (Figure 1 and 2, Appendix B-2).

Based on discussions at the February meeting and further discussion following the meeting suggest that we provided considerable more information on February 19th than was needed for the immediate Phase One questions. Therefore, a set of maps has been prepared to represent each alternative showing the relative frequency of occurrence for just the first decade for Mixed Severity Fire and Stand Replacing Fire. (Map 1 and Map 2, Appendix B-2) (We think that the managers are primarily seeking to reduce the amount of MS and SR fire in the next decade by applying fuel management treatments.) Therefore, we could combine MS and SR fire into a single map (Map 3, Appendix B-2). Furthermore, we feel the No-Action without Fire Suppression Alternative provides a better output for prioritizing stands that need treatment the most. This is a key point for manager feedback on what kind of output they would feel most important to help inform their priority decisions.

These runs were made for "average conditions". They can be run for more severe weather conditions to produce higher numbers of fire occurrence. But, relative priorities would probably be similar.

FIRE RISK without SIMPPLLE (Twer-Pfister)

The vegetation classification system used in SIMPPLLE can also be interpreted solely on the basis of relative differences in expected fire severity ("fire regimes") for different species composition, density, vertical layering, and size class. One method is to assign an expected average fire severity class to each cell in the multi-variable classification system. On can assign "Non-Lethal", "Mixed Severity" and "Stand Replacement" and interpret these as "low", "medium", and "high" fire risk stands. These can then be displayed in the GIS to provide a crude overview of fire susceptiblity based

solely on existing vegetation conditions (Map 4, Appendix B-2). This might be helpful as a starting point in communicating with the public on how much of the landscape would need to be treated to ensure that most fires would be non-lethal (and easy to control). However, the SIMPPLE model incorporates several other variables that affect the severity of a fire and the spread of fires from one polygon to another and the effects of adjacency and slope position of adjacent stands that lead us toward a better informed basis of predicting possible fire occurrence and spread.

SUMMARY STATEMENT (Pfister)

Interpretation of model applicability will require commitment and communication between researchers and managers. This is a technology transfer challenge that cannot be accomplished without direct interaction between individual researchers and individual managers. Researchers must learn from the managers the critical pieces of information needed for planning; managers must have enough understanding of each model capability to provide various outputs. TOGETHER they must evaluate alternative model outputs and INTERPRET the information relevant to specific management questions.

We understand that analysis of the entire Bitterroot Front Landscape was to be something that could be accomplished in a short period of time initially. Then we would select a smaller study area to implement a proposed action and design a more-detailed study to demonstrate and test alternative treatments, effects of alternatives, etc. Will the draft study plan clarify this two step approach?

References

Agee, J.K. 1993. The historic role of fire in Pacific Northwest forests. Island Press.

Arno, S.F. and S. Allison-Bunnell. 2002. Flames in out forest: disaster or renewal? Island Press.

Bonnicksen, T.M. 2000. America's ancient forests. Wiley and Sons, New York.

Appendix B-2: Tables, graphs, and maps of fire output from SIMPPLLE 03-26-04

Table 1: Percentage of landscape by disturbance processes, size class and density per decade w/o fire suppression

Table 2: Percentage of landscape by disturbance processes, size class and density per decade w/ fire suppression

Figure 1: Distribution of stands by size class w/o fire suppression

Figure 2: Distribution of stands by size class w/ fire suppression

Figure 3: Average acres burned per decade by fire class

Map 1: Stand replacing fires

Map 2: Mixed severity fires

Map 3: Stand replacing and mixed severity fires

Map 4: Fire regimes

Table 1

No Fire Suppression

%

PROCESS/TIME	0	1	2	3	4	5	6	7	8	9	10	11	12
SUCCESSION	100.0	71.4	68.8	68.0	65.1	66.6	65.3	65.8	64.5	69.5	64.4	61.2	66.2
ROOT-DISEASE	0.0	0.2	0.5	0.4	0.5	0.4	0.5	0.4	0.4	0.6	0.6	0.5	0.5
DF-BEETLE	0.0	1.0	0.5	0.3	0.2	0.6	0.3	0.7	0.4	0.4	0.4	0.4	0.3
SPRUCE-BEETLE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LIGHT-WSBW	0.0	1.5	0.6	0.6	0.3	0.5	0.3	0.2	0.3	0.5	0.3	0.2	0.3
SEVERE-WSBW	0.0	0.6	0.4	0.5	0.2	0.4	0.2	0.2	0.2	0.1	0.2	0.1	0.2
PP-MPB	0.0	0.5	0.6	0.6	0.9	1.6	0.7	0.7	1.3	0.9	1.3	0.5	1.6
LIGHT-LP-MPB	0.0	0.3	0.1	0.1	0.2	0.2	0.5	0.2	0.2	0.3	0.2	0.3	0.1
SEVERE-LP-MPB	0.0	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.3	0.1	0.2	0.0	0.1
WBP-MPB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WP-MPB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LIGHT-SEVERITY-FIRE	0.0	7.7	12.4	14.5	16.8	17.0	16.9	18.5	17.0	16.3	18.2	20.7	19.1
MIXED-SEVERITY-FIRE	0.0	12.8	10.1	9.4	9.1	7.4	8.5	7.3	9.1	6.5	9.1	7.9	6.9
STAND-REPLACING-FIRE	0.0	4.0	5.9	5.4	6.5	5.1	6.7	5.7	6.3	4.8	5.2	8.2	4.6

SIZE/TIME	0	1	2	3	4	5	6	7	8	9	10	11	12
SS	6.3	8.8	10.9	10.9	12.7	13.1	12.4	12.2	11.3	11.0	11.2	12.8	12.4
POLE	16.2	11.8	3.3	4.6	4.9	3.7	4.0	4.6	4.0	3.5	3.2	3.1	3.1
PTS	0.0	3.4	3.7	3.5	1.9	1.6	1.3	1.6	2.2	2.1	2.0	1.9	1.7
PMU	0.9	0.1	0.3	0.1	0.3	0.2	0.3	0.2	0.2	0.3	0.4	0.4	0.4
	17.1	15.3	7.4	8.3	7.1	5.5	5.5	6.4	6.4	6.0	5.6	5.4	5.2
MEDIUM	7.1	4.3	8.7	7.1	3.0	3.7	4.5	3.3	3.4	3.2	3.1	2.4	2.4
MTS	0.0	0.5	0.4	0.5	0.4	0.7	0.4	0.4	0.3	0.5	0.4	0.4	0.6
MMU	0.0	2.9	2.8	2.0	1.5	1.9	1.9	1.5	1.2	1.3	1.5	1.8	1.7
	7.1	7.6	11.9	9.6	5.0	6.3	6.8	5.1	4.8	5.0	5.0	4.5	4.6
LARGE	9.4	14.4	18.8	19.9	22.6	21.8	20.3	21.3	22.5	22.9	23.2	22.9	22.4
LTS	0.0	0.9	1.1	1.8	1.7	1.9	1.7	1.6	1.3	1.2	1.0	1.4	1.4
LMU	9.9	8.2	5.9	6.7	7.7	7.8	6.9	6.3	5.6	5.5	5.1	4.8	5.5
	19.3	23.4	25.8	28.3	32.0	31.5	28.9	29.2	29.5	29.6	29.4	29.0	29.3
V-LARGE	0.2	0.5	0.4	0.5	0.8	0.8	0.8	1.0	1.1	1.0	1.0	1.4	1.1
VLTS	3.5	1.5	1.2	0.8	0.4	0.4	0.5	0.3	0.4	0.6	0.6	0.6	0.8
VLMU	6.9	3.0	1.8	1.0	1.6	2.0	4.1	5.0	4.9	4.8	5.1	4.8	5.0
	10.5	5.0	3.4	2.3	2.8	3.1	5.4	6.3	6.5	6.5	6.7	6.8	7.0
NF	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6
NS	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DENSITY/TIME	0	1	2	3	4	5	6	7	8	9	10	11	12
1	39.6	39.7	40.5	40.6	40.4	40.5	41.0	40.8	41.5	42.0	42.0	41.5	41.5
2	44.7	35.5	31.7	30.4	30.6	28.7	27.5	27.5	27.6	27.1	28.4	27.9	27.5
3	12.4	18.6	14.5	11.4	9.0	9.6	9.3	7.4	7.0	6.6	5.4	6.0	6.1
4	3.3	6.1	13.3	17.6	20.0	21.2	22.2	24.3	23.9	24.3	24.1	24.6	24.9

Table 2

Fire Suppression

%

PROCESS/TIME	0	1	2	3	4	5	6	7	8	9	10	11	12
SUCCESSION	100.0	89.2	90.3	91.7	90.2	87.6	88.2	87.2	86.5	85.7	85.7	86.7	84.4
ROOT-DISEASE	0.0	0.3	0.7	1.0	1.4	1.7	2.0	2.4	2.9	3.3	3.4	3.7	3.5
DF-BEETLE	0.0	1.3	0.8	0.4	0.4	0.8	0.7	0.5	0.5	0.6	0.5	0.4	0.4
SPRUCE-BEETLE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LIGHT-WSBW	0.0	2.2	1.4	1.2	1.2	2.1	1.5	1.6	2.1	1.6	1.5	1.6	1.4
SEVERE-WSBW	0.0	1.8	1.1	1.2	1.5	2.0	1.7	1.7	1.9	1.7	1.6	1.8	1.4
PP-MPB	0.0	0.7	0.4	0.8	0.5	0.9	0.8	1.3	0.9	1.4	1.9	1.1	1.7
LIGHT-LP-MPB	0.0	0.4	0.3	0.1	0.3	0.8	0.5	0.6	0.4	0.3	0.4	0.2	0.2
SEVERE-LP-MPB	0.0	0.6	0.2	0.4	0.1	0.3	0.5	0.3	0.2	0.3	0.1	0.1	0.1
WBP-MPB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WP-MPB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LIGHT-SEVERITY-FIRE	0.0	1.1	1.9	1.2	1.6	1.3	1.4	1.5	2.0	1.6	1.8	1.6	2.1
MIXED-SEVERITY-FIRE	0.0	1.8	2.0	1.6	2.0	1.8	1.9	1.6	1.5	2.1	1.6	1.9	2.1
STAND-REPLACING-FIRE	0.0	0.7	0.7	0.5	0.7	0.7	0.9	1.3	1.1	1.5	1.5	0.9	2.6

SIZE/TIME	0	1	2	3	4	5	6	7	8	9	10	11	12
SS	6.3	7.9	7.5	4.9	5.0	4.2	3.7	4.1	4.1	5.1	5.1	4.6	5.3
POLE	16.2	11.5	2.4	4.1	3.7	1.4	2.3	2.8	1.8	1.5	1.3	1.1	1.5
PTS	0.0	4.3	5.6	7.4	5.5	3.4	1.9	1.5	1.8	1.3	1.6	1.9	1.9
PMU	0.9	0.1	0.4	0.7	1.0	1.3	1.5	1.9	2.1	2.5	2.8	3.1	3.1
	17.1	15.9	8.3	12.3	10.2	6.0	5.7	6.2	5.7	5.3	5.7	6.0	6.5
MEDIUM	7.1	4.4	9.6	7.6	2.2	4.4	3.9	1.6	2.2	1.8	1.9	2.2	1.6
MTS	0.0	0.3	0.2	0.1	0.8	0.5	0.8	0.6	0.6	0.4	0.5	0.2	0.2
MMU	0.0	3.6	5.2	3.8	3.0	5.5	5.8	3.7	2.9	2.9	2.6	2.8	2.3
	7.1	8.3	15.0	11.5	5.9	10.4	10.5	5.9	5.7	5.1	5.0	5.1	4.1
LARGE	9.4	10.1	12.4	13.2	19.1	19.4	17.3	18.1	18.7	18.6	18.9	19.0	19.0
LTS	0.0	1.4	1.7	2.2	2.3	2.3	2.5	2.1	2.1	1.9	1.9	1.8	1.8
LMU	9.9	9.9	10.2	13.3	14.5	14.9	15.8	14.3	14.0	14.0	11.5	10.3	9.6
	19.3	21.4	24.3	28.6	35.9	36.6	35.6	34.5	34.8	34.5	32.2	31.1	30.4
V-LARGE	0.2	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.6	0.7	0.7	0.8	1.0
VLTS	3.5	2.5	2.1	1.2	1.0	0.7	0.5	0.5	0.4	0.3	0.3	0.2	0.2
VLMU	6.9	4.9	3.8	3.3	3.6	3.4	5.0	10.1	10.7	11.0	13.0	14.0	14.5
	10.5	7.6	5.9	4.6	5.0	4.4	6.0	11.1	11.7	12.0	14.0	15.1	15.7
NF	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6
NS	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DENSITY/TIME	0	1	2	3	4	5	6	7	8	9	10	11	12
1	39.6	38.9	38.9	38.1	38.1	38.4	38.5	38.1	38.1	38.0	38.0	38.0	38.0
2	44.7	32.1	25.6	23.3	23.7	24.4	24.4	23.4	24.4	25.0	25.0	25.6	25.3
3	12.4	22.0	19.7	16.9	15.4	13.8	12.0	10.6	7.5	7.0	7.2	6.9	7.0
4	3.3	6.9	15.8	21.7	22.8	23.3	25.1	27.8	30.1	30.0	29.8	29.4	29.7

Figure 1

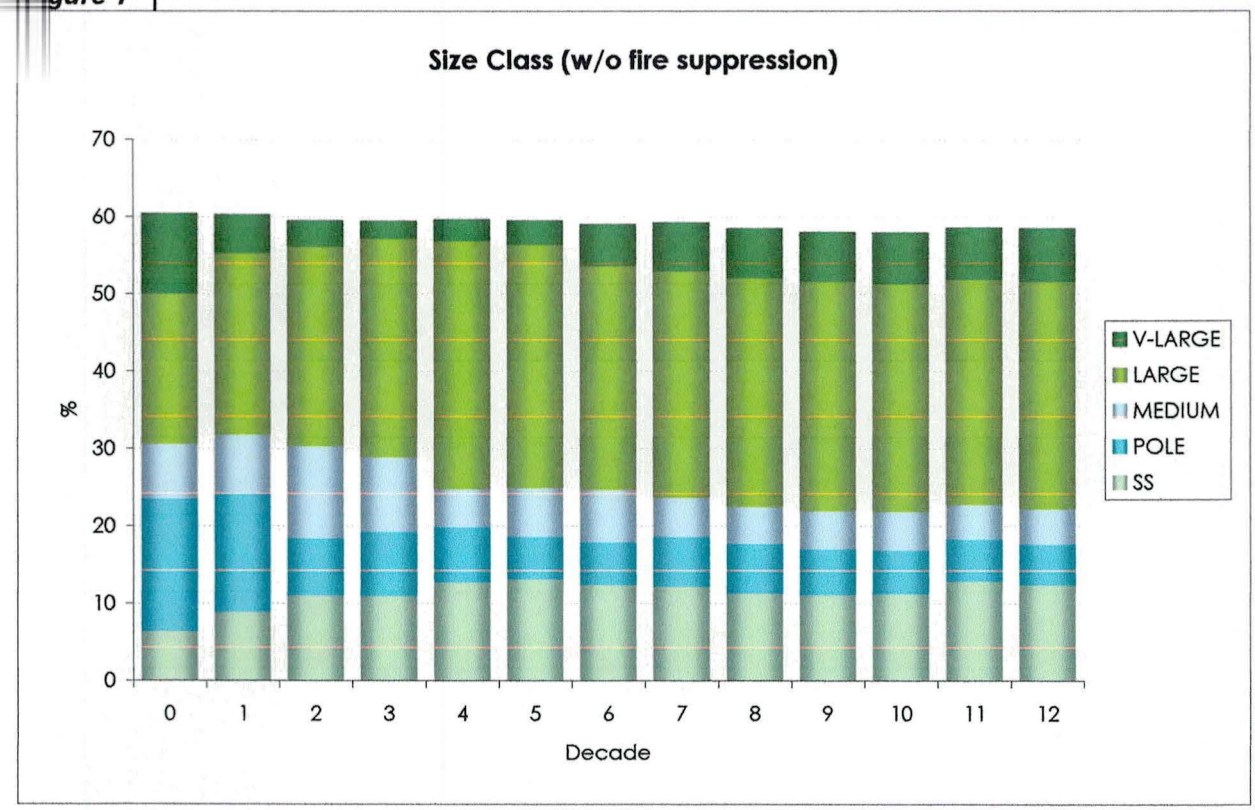


Figure 2

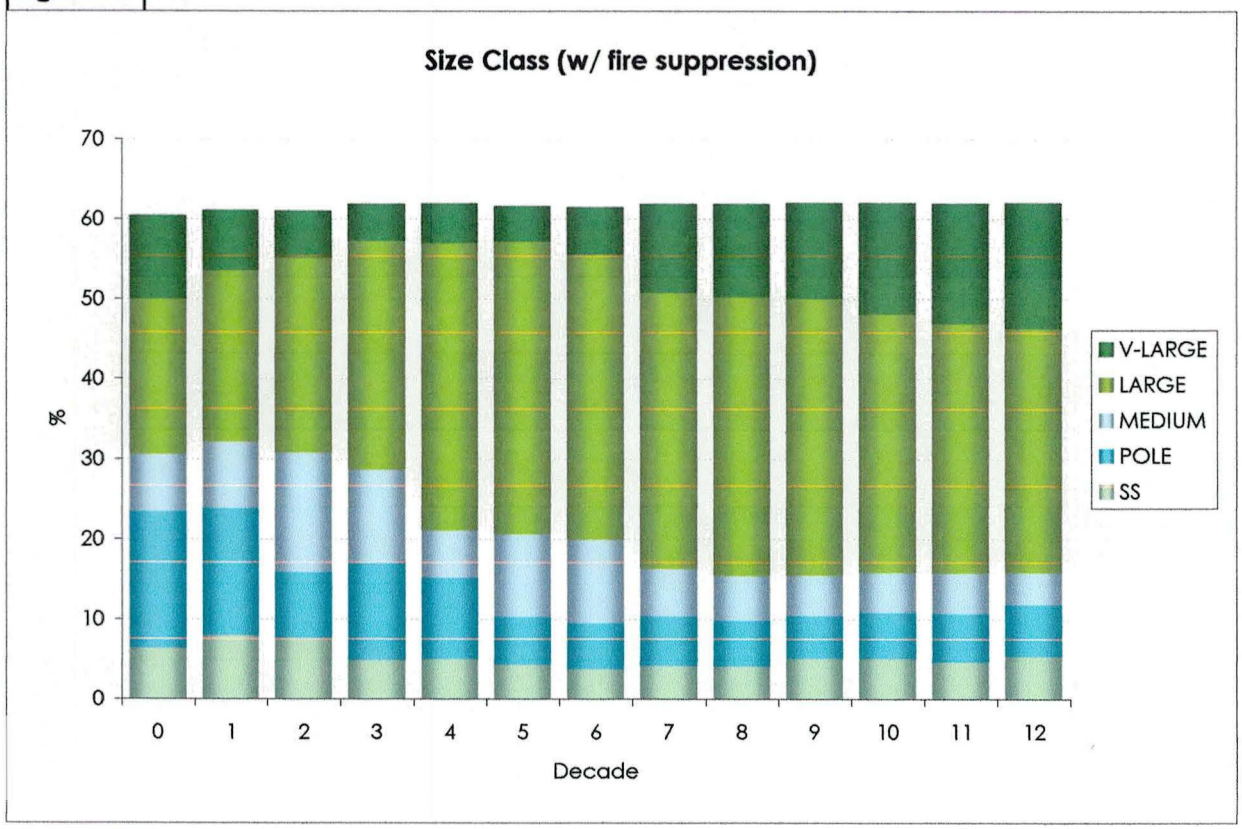
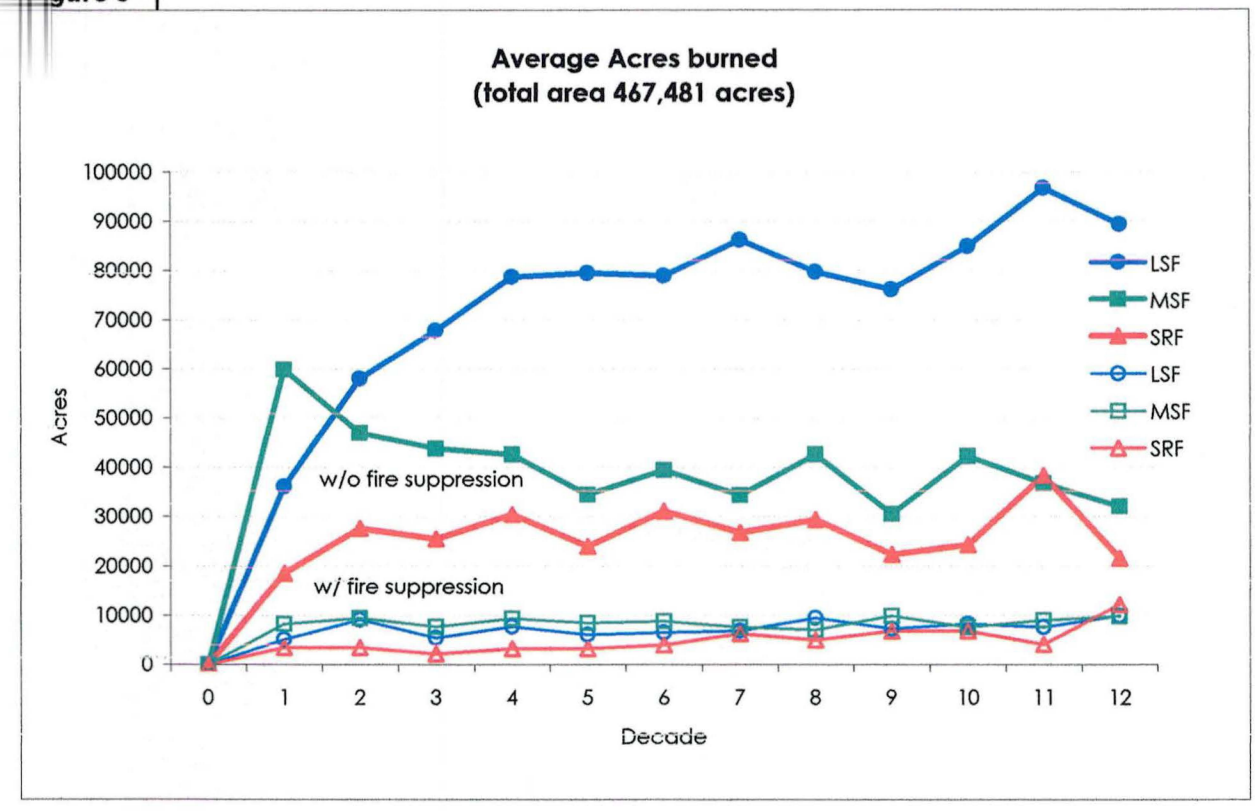


Figure 3


Average Acres burned
(total area 467,481 acres)
Acres
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0
1
2
3
4
5
6
7
8
9
10
11
12
Decade
w/o fire suppression
w/ fire suppression
LSF
MSF
SRF
LSF
MSF
SRF

Map 1

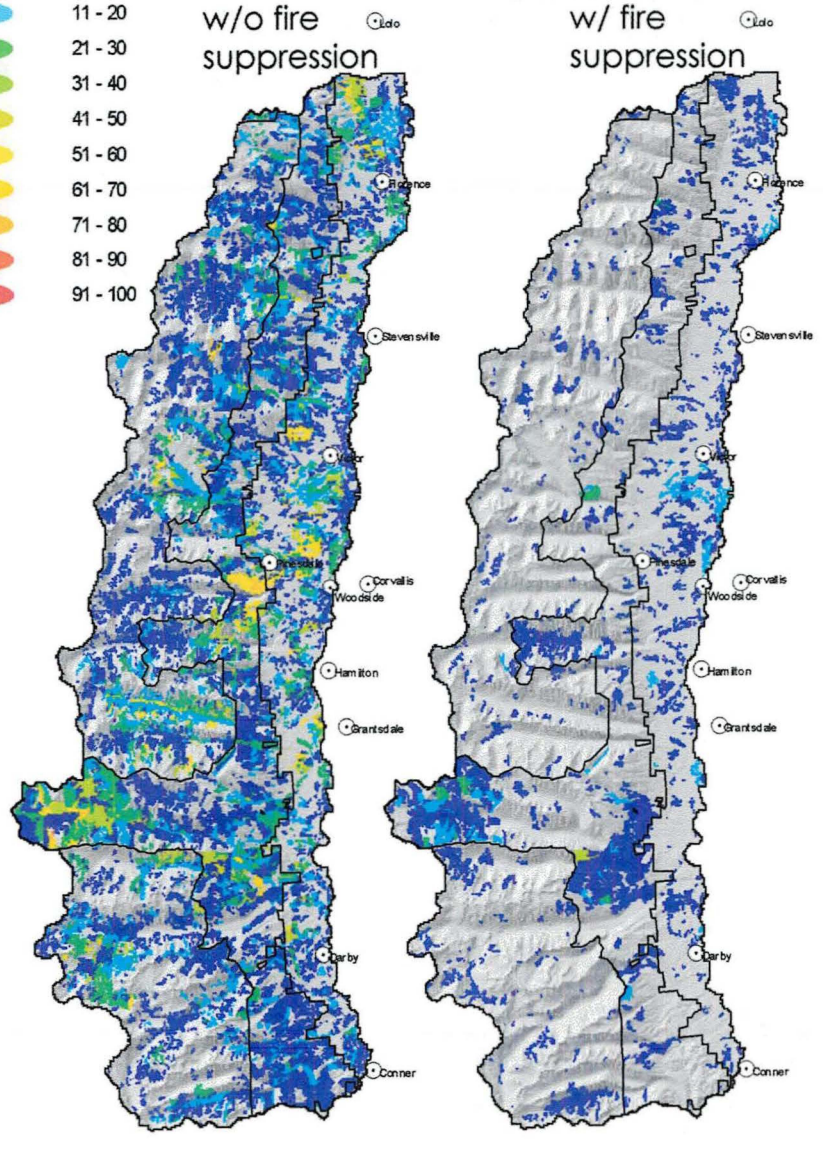
SIMPPLLE output — decade

Map 2

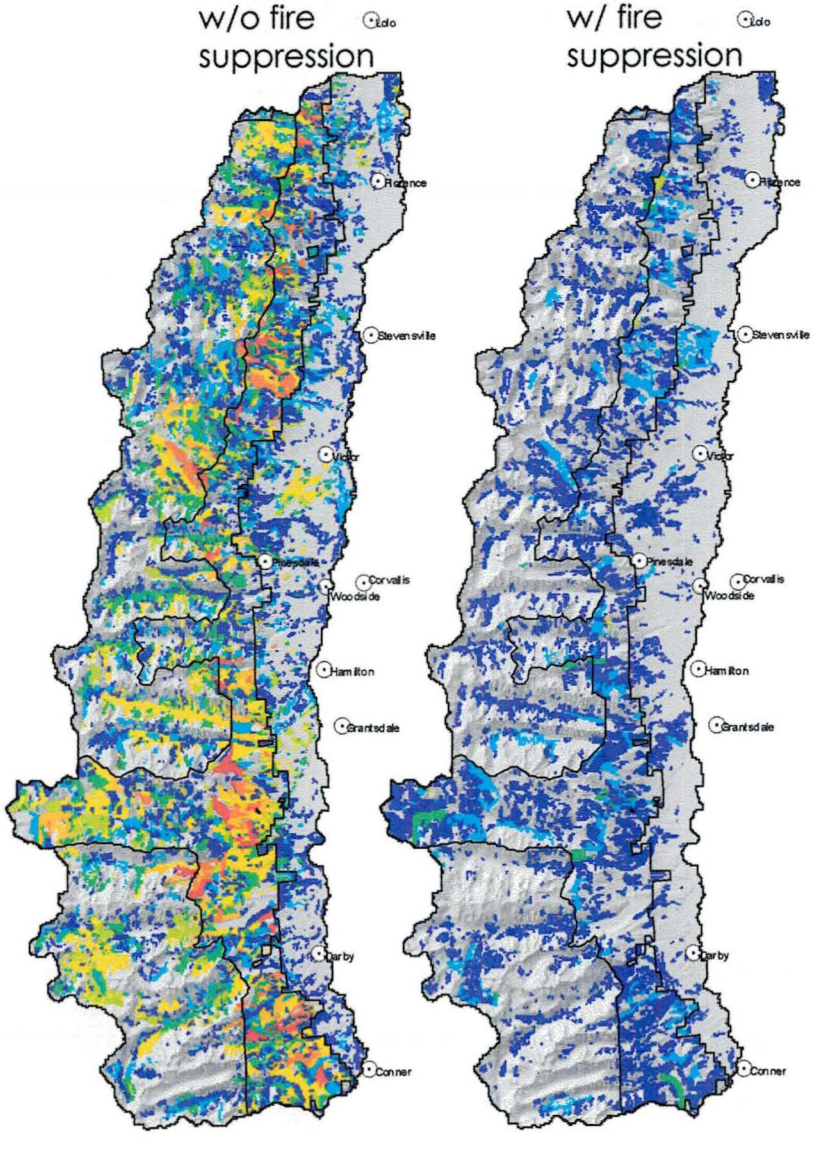
Relative frequency %

0
1 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 70
71 - 80
81 - 90
91 - 100

Stand replacing fires



Mixed severity fires



Map 3

SIMPPLLE output 1st decade

Stand replacing + mixed severity fires

Relative frequency

%

0

1 - 10

11 - 20

21 - 30

31 - 40

41 - 50

51 - 60

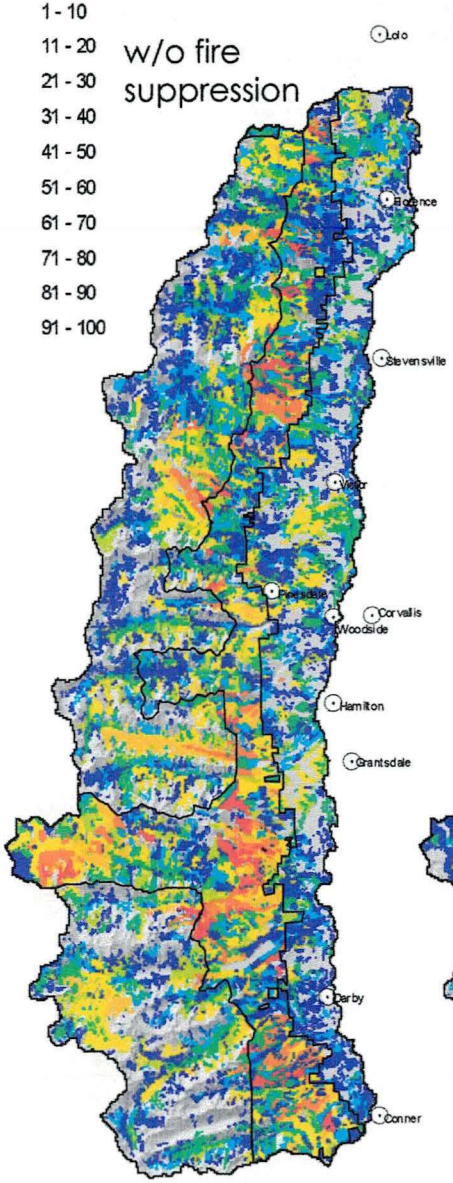
61 - 70

71 - 80

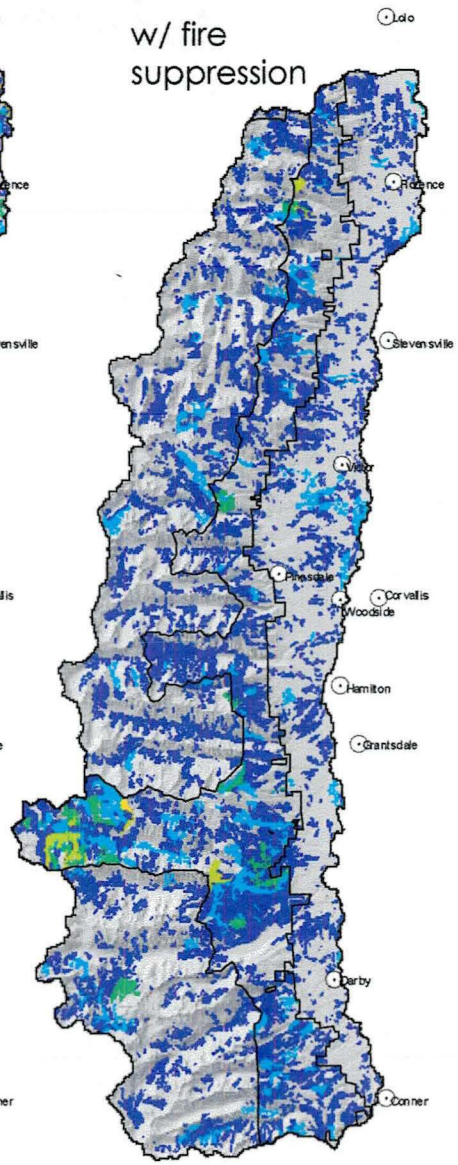
81 - 90

91 - 100

w/o fire suppression



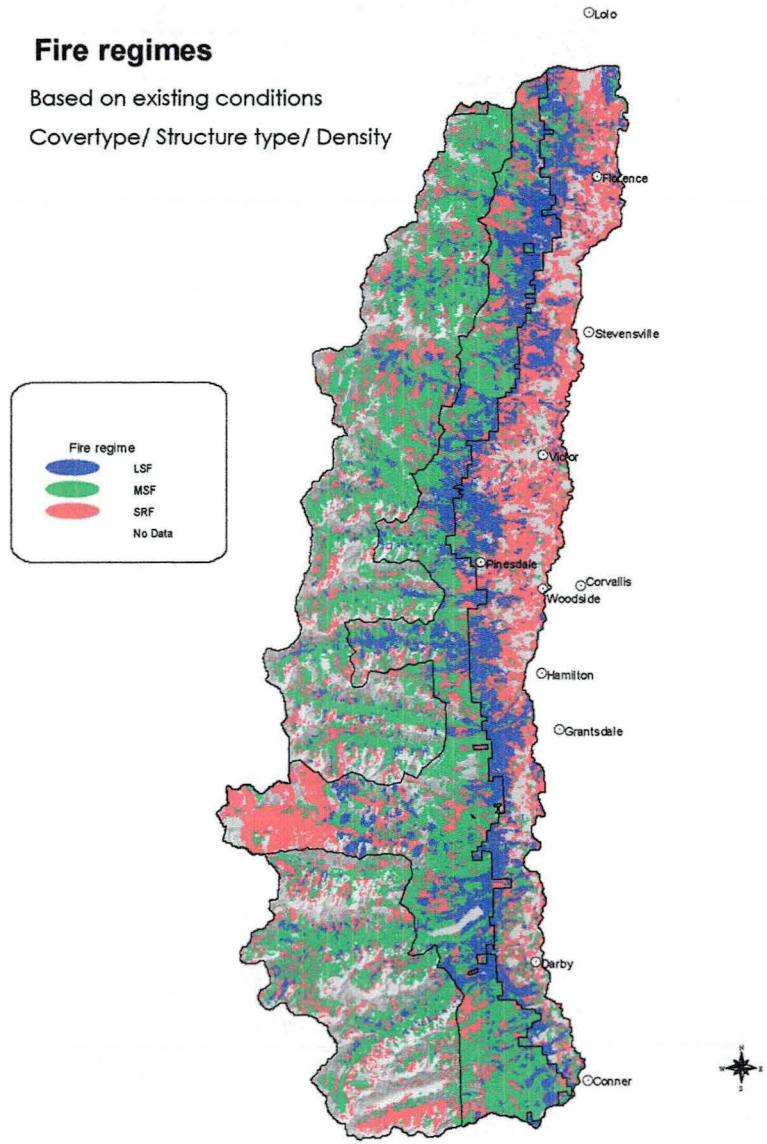
w/ fire suppression



Fire regimes

Based on existing conditions

Covertype/ Structure type/ Density



Appendix C – Pathway times for BNF/FIA/FVS database and SIMPPLLE.

(RJVA Task D. 1. d. – *"Collaborate with the Rocky Mountain Station to select a representative sample of available stand inventory data (tree lists) and run the Forest Vegetation Simulator (FVS) to make comparisons with appropriate successional pathways in the SIMPPLLE model."*

Background

The SIMPPLLE model was designed to operate with stand types based on four parameters: 1) Dominance Type, 2) Diameter Size Class, 3) Density (Canopy Cover) Class, and 4) Vertical Structure Class (Chew and others 2003). Basic "succession pathways" are provided in the model to represent normal stand development changes by decades. These basic pathways were originally developed empirically from available data in the Northern Region database and stand projections with the FVS growth and yield model. (Chew 1995). SIMPPLLE operates in decadal time steps with orderly progression of stands moving into larger Size Classes and increasing Density (Canopy Cover) Classes. These are represented in the model as the number of decades that each stand type stays within the type if a stochastic disturbance is not selected based on probabilities of each disturbance type.

The Size Class stand variable was of primary interest for this exercise using Bitterroot National Forest 1995 FIA data set (226 forest stands) and running the Forest Vegetation Simulator for 12 decades to observe changes in Size Class over time and compare these with the ones currently in the SIMPPLLE model.

This appeared to be a relatively straight-forward approach to begin with. However, numerous problems have been encountered:

1) SIMPPLLE was designed to be consistent with stand classification standards being used by the Northern Region. However, these standards are in the process of change.

2) Diameter Size Classes were traditionally broken at 5", 7", 9", 14" and 21". These were later modified to drop the 7" break (Chew and others 2003). Current recommended National Forest Service Standards have breaks at 5", 10", 15", 20" and 25" (Brohman and Bryant 2004).

3) Methods for placing individual stands into a standard Size Class are not consistent as demonstrated clearly at the Northern Region Vegetation Classification Panel Workshop in October 2002 (USFS-R1 2003). Participants visited many stands recently sampled for the mid-level Northern Region Vegetation Classification and Mapping Program. The participants had field data in hand, data summaries, aerial photos, and stand type calls generated by several different algorithms. Each participant independently made a classification (identification) call for the four variables described above. The results illustrated considerable variablility and the need for standardizing the methods for placing individual stands into stand types, especially for the Size Class

category. A follow-up report provided additional recommendations regarding Dominance Type and Size Type classification (Pfister 2003).

4) The Northern Region Vegetation Council currently recommends a new variable be calculated for Size Class called "BA weighted DBH" (USFS-R1 2005). The basal area for each tree size class are multiplied by the size class # to give greater weights to the larger trees in the stand. The sum of weighted BA by size class is divided by total BA to determine a BA weighted average DBH.

5) Computational determination of Size Class may be theoretically the most consistent, but it is frustrating to not have a simple method that could also be used directly while in the field. Alternatives have been suggested based on average of dominant tree diameters or average diameter of the 40 largest trees/acre in the stand ("top diameter" similar to "top height"), but these have not been provided as output from stand summary software packages for comparison purposes.

6) The purposes for Size Class have not been clearly articulated. For example, FIA places stands in size classes by a complicated computer algorithm involving plurality of basal area stocking which is probably most appropriate for their goals (Arner and others 2001). On the other hand, Size Class type is used widely for landscape ecology and planning as a surrogate for age class of stands. Age class is difficult to determine, but size class change with time is a useful tool for landscape application and modeling.

Size Classes for FVS projections of Bitterroot FIA data –

The Northern Region Vegetation Council Workshop Report in 2002 documented problems with using the DESCRIBE model for classifying stands (USFS-R1 2003) . Following the workshop an effort was made by the Vegetation Council to develop computer algorithms to classify stands based on inventory data and stand projections with FVS (USFS-R1 2005). Martin Twer had problems running the Northern Region Stand Classifier programs on our computer in the spring of 2005 and finally asked Rene Lundgren to run our Bitterroot FIA dataset and FVS output with their program. Their classification output became available to us in the summer of 2005 for examination of # of decades that stands stayed in a size class.

We used the part of the R-1 Classifier output which relies primarily on the "BAweightedDBH" related to traditional R-1 and SIMPPLLE Size Classes. We then extracted two size class variables from our FVS output for comparison purposes: 1) 90th percentile DBH, and 2) Strata 1 DBH. We also added additional information from previous FVS output (such as canopy cover, basal area, and volumes) to help visualize stand structure conditions. These were condensed into a one-page wide format for visual examination. The first 24 of 226 stands (FIA plots) were examined by hand for three size class variables. Columns were highlighted in color to examine number of decades residency in a size class. Table C-1 illustrates the format of the 24 stand summaries in Appendix C-2.

"Table C-1. p.1 of A. C-2.xls"

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1	Setting ID	Cy	EI DT	EI-SIM	ForTy	Size	SZC	Size	SZCI	Ve	StrCl	T BA	TPA	QMD	BAw DB		Cov	DEN	HTG	90th	SZ_C	TOT CU	MERC	MeBF	Str T D
2	161304900331	0	ES-DF	DF-ES	ES	5.0-	POL	5.0-	POLI	1	POLE	13.7	976	1.6	6.9		18	2	C1	1.7	SS	150	45	156	1.8
3	161304900331	1	ES-DF	DF-ES	ES	5.0-	POL	5.0-	POLI	1	POLE	19.8	918	2.0	7.4		24	2	C1	2.1	SS	234	70	156	4.3
4	161304900331	2	ES-GF	ES	ES	5.0-	POL	5.0-	POLI	C	PMS	39	816	3.0	8.1		40	3	C1	3.8	SS	499	199	735	7.0
5	161304900331	3	ES	ES	ES	5.0-	POL	5.0-	POLI	C	PMS	69.5	836	3.9	8.5		56	3	C1	5.9	POL	997	506	1856	8.1
6	161304900331	4	ES	ES	ES	5.0-	POL	9.0-	MED	C	MMS	111	773	5.1	9.2		67	3	C1	7.7	POL	1781	924	3525	10.0
7	161304900331	5	ES	ES	ES	10.0	MEI	9.0-	MED	C	MMS	158	825	5.9	10.4		74	4	C1	7.9	POL	2829	1621	7228	13.7
8	161304900331	6	ES	ES	ES	10.0	MEI	9.0-	MED	2	MTS	195	727	7.0	11.2		76	4	C1	10.9	MEI	3788	2370	9791	15.3
9	161304900331	7	ES	ES	ES	10.0	MEI	9.0-	MED	C	MMS	223	715	7.6	12.1		77	4	C1	11.6	MEI	4658	3049	13464	16.8
10	161304900331	8	ES	ES	ES	10.0	MEI	9.0-	MED	C	MMS	244	611	8.6	12.9		77	4	C1	13.2	MEI	5444	4074	19555	18.3
11	161304900331	9	ES	ES	ES	10.0	MEI	9.0-	MED	1	MED	262	647	8.6	13.8		76	4	C1	14.0	MEI	6228	4900	23791	19.4
12	161304900331	10	ES	ES	ES	10.0	MEI	14.0	LARG	C	LMS	278	533	9.8	14.8		75	4	C1	15.4	LAR	7026	5773	27840	20.5
13	161304900331	11	ES	ES	ES	15.0	LAR	14.0	LARG	C	LMS	288	526	10.0	15.9		74	4	C1	15.9	LAR	7717	6487	32647	20.1
14	161304900331	12	ES	ES	ES	15.0	LAR	14.0	LARG	C	LMS	295	435	11.2	16.7		72	4	C1	18.1	LAR	8292	7084	36504	20.7
15	161304900331	13	ES	ES	ES	15.0	LAR	14.0	LARG	C	LMS	300	472	10.8	17.4		71	4	C1	17.0	LAR	8826	7673	40015	23.0
16														###											
17	161304900362	0	DF	DF	DF	10.0	MEI	9.0-	MED	C	MMS	73.4	1002	3.7	11.8		38	2	B2	7.9	POL	1917	1656	8202	11.3
18	161304900362	1	DF	DF	DF	10.0	MEI	9.0-	MED	C	MMS	86	909	4.2	12.4		41	3	B2	8.8	POL	2319	2001	10362	13.6
19	161304900362	2	DF	DF	DF	10.0	MEI	9.0-	MED	2	MTS	107	746	5.1	13.6		46	3	B2	11.6	MEI	3110	2716	14097	14.5
20	161304900362	3	DF	DF	DF	10.0	MEI	14.0	LARG	2	LTS	128	829	5.3	14.8		54	3	B2	12.0	MEI	3948	3411	17869	15.6
21	161304900362	4	DF	DF	DF	15.0	LAR	14.0	LARG	C	LMS	147	687	6.3	15.6		59	3	B2	13.7	MEI	4707	4085	22078	17.5
22	161304900362	5	DF	DF	DF	15.0	LAR	14.0	LARG	C	LMS	164	625	6.9	16.3		63	3	B2	15.5	LAR	5440	4742	26137	18.2
23	161304900362	6	DF	DF	DF	15.0	LAR	14.0	LARG	2	LTS	179	528	7.9	16.9		66	3	B2	16.7	LAR	6088	5261	29488	19.0
24	161304900362	7	DF	DF	DF	15.0	LAR	14.0	LARG	2	LTS	192	555	8.0	17.7		67	3	B2	17.8	LAR	6737	5852	33039	21.4
25	161304900362	8	DF	DF	DF	15.0	LAR	14.0	LARG	2	LTS	203	459	9.0	18.3		68	3	B2	19.0	LAR	7320	6321	36420	21.8
26	161304900362	9	DF	DF	DF	15.0	LAR	14.0	LARG	2	LTS	213	539	8.5	18.4		68	3	B2	18.5	LAR	7843	6686	39068	23.1
27	161304900362	10	DF	DF	DF	15.0	LAR	14.0	LARG	2	LTS	223	440	9.6	19.2		69	3	B2	20.3	LAR	8372	7241	43005	23.4
28	161304900362	11	DF	DF	DF	15.0	LAR	14.0	LARG	2	LTS	233	477	9.5	19.2		70	4	B2	19.7	LAR	8891	7954	47443	23.8
29	161304900362	12	DF	DF	DF	20.0	V-L	14.0	LARG	2	LTS	242	390	10.7	19.3		71	4	B2	21	V-LA	9372	8439	51242	24.0
30	161304900362	13	DF	DF	DF	20.0	V-L	14.0	LARG	2	LTS	250	422	10.4	19.3		71	4	B2	21	V-LA	9833	8896	53703	24.0
31														###											
32																									

A comparison of initial conditions ("Start") and final conditions ("End") of the 24 stands are presented in Table C-2. The stands selected represented a wide variety of Ages, Habitat Type Groups (HTG), Elementary Dominance Types (ElDT), and stand structural characteristics. The three variables for Size Type (BAwDBH, 90th Percentile DBH, and Strata 1 DBH) were often in agreement for Initial Conditions ("Start") and for Final Conditions ("End"). However, several two-storied or multi-storied stands were classified as Seedling/Sapling (SS) by the 90th Percentile, and Pole (P) or Medium (M) by Basal Area weighted DBH (e.g. Stands 331, 401, 473, 474, and 502). However, this comparison is rather superficial because considerable variation in pathway residence times was evident in the period from 1995 to 2120 as shown in Appendix C-2.

"Table C-2.xls"

An attempt was made to document the residence times for each size class for the three Stand Size classifier variables by hand examination of Appendix C-2. Table C-3 presents a summary of these examinations for the three size class variables: 1) BAwDBH, (left side-column F) 2) 90th percentile DBH (middle-column L), and 3) Strata 1 DBH (right side-column R). Documentation was provided for the number of decades observed in given size class and estimates were made for the total residence time in a size class when the initial conditions were midway within a size class.

"Table C-3.xls"

Although the general progression was similar, the residence time varied greatly by the three Size Class variables. This exercise was discontinued after laboriously looking at the first 24 of 226 stands because of three main problems:

1) The three Size Class variables provided from the R-1 Stand Classifier and FVS output are not the same as used in the current version of SIMPPLLE (Chew and others 2003) and the DESCRIBE software for assigning stands to types used previously was not used in the R-1 Classifier output because of previously documented problems (USFS-R1 2003).

2) The 226 FIA stands would be a very small sample to obtain sufficient replicates within Habitat Type Group, Dominance Type, Density, and Vertical Stucture to test the current SIMPPLLE Size Class Pathways, and

3) The matter of standardizing assignment of Size Class is not completely resolved, although the Northern Region Vegetation Council is currently using BA-weighted DBH for their mid-scale vegetation classification and mapping program. (USFS-R1 2005).

In order to generalize the relationship among the observed Stand Size variables, 18 of the 24 stands were selected for graphical comparison purposes. These were younger stands that progressed through several Size Classes in the process of stand development represented by the FVS model. (Older stands that started as Large or Very Large were removed for this analysis because they spent most of the time in the Very

Table C-2. Summary of comparison of BNF FIA/FVS size classes for initial conditions (1995) and final conditions ((2120).

	A	B	C	D	E	F	G	H	I	J	K
1	Location ID	Orig. Yr.	HTG	EI DT	Stand Description	BAwDBH	Performance	90th%	Perform	Str T D	Perform
2											
3	Start 331	1971	C1	ES-DF	Young, open with overstory Reserves to	P	?	SS	okay	SS	okay
4	End 331			ES-DF	Large, closed, multi-story stand	L	low	L	low	VL	okay
5											
6	Start 362	1952	B2	DF	Middle-aged, dense, multistoried to	M	okay	P	?	M	okay
7	End 362			DF	Older, closed, two-storied	L	low	VL	okay	VL	okay
8											
9	Start 363	1995	B1	NS	Establishing stand, non-forest, to	NS	okay	SS	okay	SS	okay
10	End 363			DF	older, closed, even-aged stand	L	okay	L	okay	VL	okay
11											
12	Start 364	1879	B1	DF	Old, open, two-storied stand to	VL	okay	VL	okay	L	?
13	End 364			DF	Older, mod. Open, two-storied stand	VL	okay	VL	okay	VL	okay
14											
15	Start 365	1952	F1	AF-LP	Middle-aged, open, multi-storied to	M	okay	SS	low !	P	low
16	End365			AF	Older, slow-growing, mod. Open, MMS	M	okay	M	okay	P	low
17											
18	Start 366	1917	B2	DF	Old, open, two-storied to	L	?	M	okay	M	okay
19	End 366	366		DF	Older, mod. Open, two-storied	VL	okay	VL	okay	VL	okay
20											
21	Start 397	1883	C2	GF-PP	Old, open, GF-PP two-storied to	M	okay	SS	low	M	okay
22	End 397			GF-PP	Older, mod. Open, Multi-storied	L	okay	L	okay	L	okay
23											
24	Start 398	1973	C2	DF	Younger, open, two-storied to	M	okay	M	okay	M	okay
25	End 398			DF	Older fast-growing, dense, multi-storied	VL	okay	VL	okay	VL	okay
26											
27	Start 400	1830	B1	DF	Old, mod. Open, multi-storied to	L	okay	L	okay	L	okay
28	End 400	400		DF	Olde, mod. Open, multi-storied	VL	okay	VL	okay	VL	okay
29											
30	Start 401	1895	B2	PP-DF	Old, mod. Open, PP-DF two-storied to	VL	okay	SS	low	VL	okay
31	End 401			DF	Older, closed, DF multi-storied	VL	okay	P	low	VL	okay
32											
33	Start 402	1923	C2	DF	Middle-age, closed, DF two-storied	L	okay ?	P	low	M	okay ?
34	End 402			DF	Older, closed DF multi-storied	VL	okay	VL	okay	VL	okay
35											
36	Start 434	1872	B2	DF	Old, mod. Open, Large, multi-storied to	L	okay	L	okay	L	okay
37	End 434				Older, mod. Open, multi-storied	VL	okay	VL	okay	VL	okay

Table C-2. Summary of comparison of BNF FIA/FVS size classes for initial conditions (1995) and final conditions ((2120).

	A	B	C	D	E	F	G	H	I	J	K
38											
39	Start 435	1933	B2	DF	Middle-age, mod.Open, MS to	P	okay	P	okay	P	okay
40	End 435			DF	Older, mod.Open, single-storied	L	okay	L	okay	L	okay
41											
42	Start 436	1916	B2	DF	Old, mod.Open, single-storied	M	okay	M	okay	M	okay
43	End 436			DF	Older, mod.Open, single-storied	VL	okay	VL	okay	VL	okay
44											
45	Start 438	1849	F1	AF-DF	Old, open, two-storied AF-DF to	M	okay	SS	low	M	okay
46	End 438			AF	DF, M or L, mod.Open, two-storied	L	okay	M	low ?	L	okay
47											
48	Start 439	1862	F1	AF	Old, mod.Open, two-storied to	M	okay	SS	low	M	okay
49	End 439			AF	Older, mod.Open, two-storied	L	okay	M	low	L	okay
50											
51	Start 469	1930	C1	LP	Middle-aged, mod.Open, multi-storied to	M	okay	P	low	M	okay
52	End 469			LP-DF	Older, mod.Open, 2 species, multi-story	L	okay	L	okay	L	okay
53											
54	Start 470	1848	D3	ES	Old, mod.Open, multi-storied to	VL	okay	P	low	VL	okay
55	End 470			ES	Older, mod.Open,	VL	okay	L	erratic	VL	okay
56											
57	Start 471	1812	B2	DF	Very old, open, single-story to	VL	okay	VL	okay	VL	okay
58	End 471			DF	Very old, open, single-story	VL	okay	VL	okay	VL	okay
59											
60	Start 472	1879	B2	DF	Old, mod.Open, multi-storied to	L	okay	L	okay	VL	okay
61	End 472			DF	Older, mod.Open, single-story	VL	okay	VL	okay	VL	okay
62											
63	Start 473	1911	B3	DF-LP	Old, mod.Open, multistory to	P	okay	SS	low	P	okay
64	End 473			DF-LP	Older, mod.Open, multi-storied	M	low ?	M	low ?	L	okay
65											
66	Start 474	1948	F1	AF	Middle-aged, open, multi-storied	P	okay	SS	low	M	high
67	End 474			AF	Older, mod.Open, slow-growing, Mstory	M	okay	M	okay	M	okay
68											
69	Start 502	1862	F1	DF	Old, closed, multi-storied to	M	okay	SS	low	M	okay
70	End 502			DF-LP	Older, closed, multi-storied DF-LP	L	okay	M	low	L	okay
71											
72	Start 503	1902	C1	LP	Old, mod.Open, multi-storied to	P	okay	P	okay	P	okay
73	End 503			LP	Older, open, single-storied	L	okay	L	okay	L	okay

Large Size Class. The six stands removed were # 364, 400, 434, 470, 471, and 472.) (Ages for the stands were obtained from FIA/FVS database and are listed in Table C-2.)

The relationships among three Size Class variables are illustrated in Figure C-1 which was charted from Appendix C-2. The BA weighted DBH variable is used as the X axis because it is the current standard provided by the Northern Region Vegetation Council (USFS-RI 2005). Strata 1 DBH is generally a larger diameter than BA weighted DBH, especially for larger (older) stands. The 90th percentile DBH is generally lower than BA weighted DBH. It is considerably lower when less than 10 percent of the total number of trees are found in the dominant layer. This happens when there are large numbers of small trees such as in stand 401. The general agreement between BA weighted DBH and Strata 1 DBH is promising and could perhaps be improved by adjusting the Strata criteria in FVS. However, their use as a surrogate for "Age Class" to represent stand development remains questionable.

Figure C-2 presents a similar illustration with the addition of Quadratic Mean Diameter (QMD). It becomes very obvious from this illustration that QMD is rather meaningless to represent stand development (secondary succession) over time.

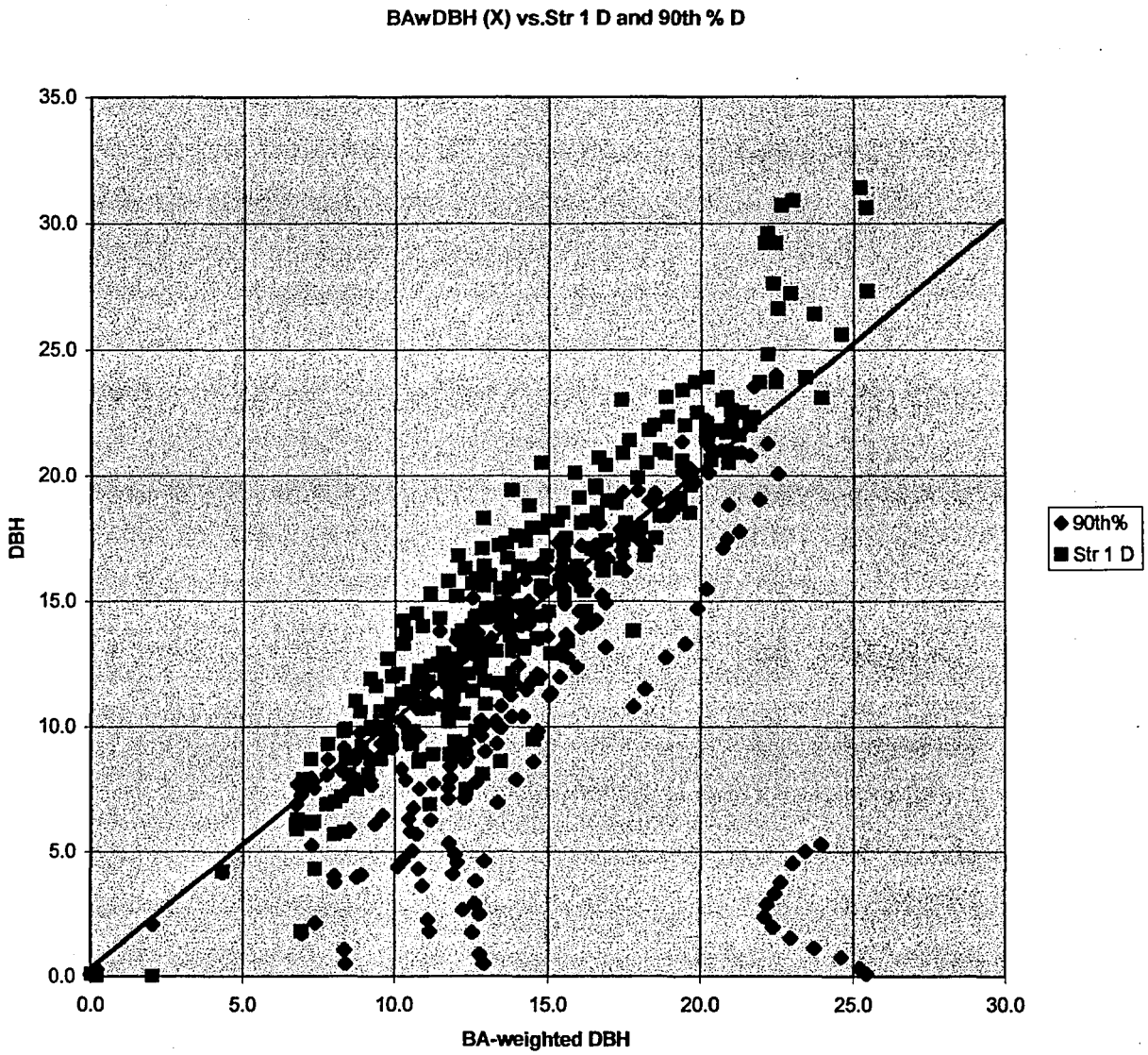


Figure C-1. Comparison of three stand-size classifier variables for 18 BNF FIA/FVS plots. Strata 1 DBH is generally higher than BA-weighted DBH, especially in the larger size stands. The 90th percentile DBH is similar to BA-weighted DBH unless there are less than 5 percent of the total number of trees in the dominant canopy, which happened frequently. Outliers in the lower right are from Plot 401 which had 8,956 trees per acre for initial conditions! Outliers in the upper right are also from Plot 401.

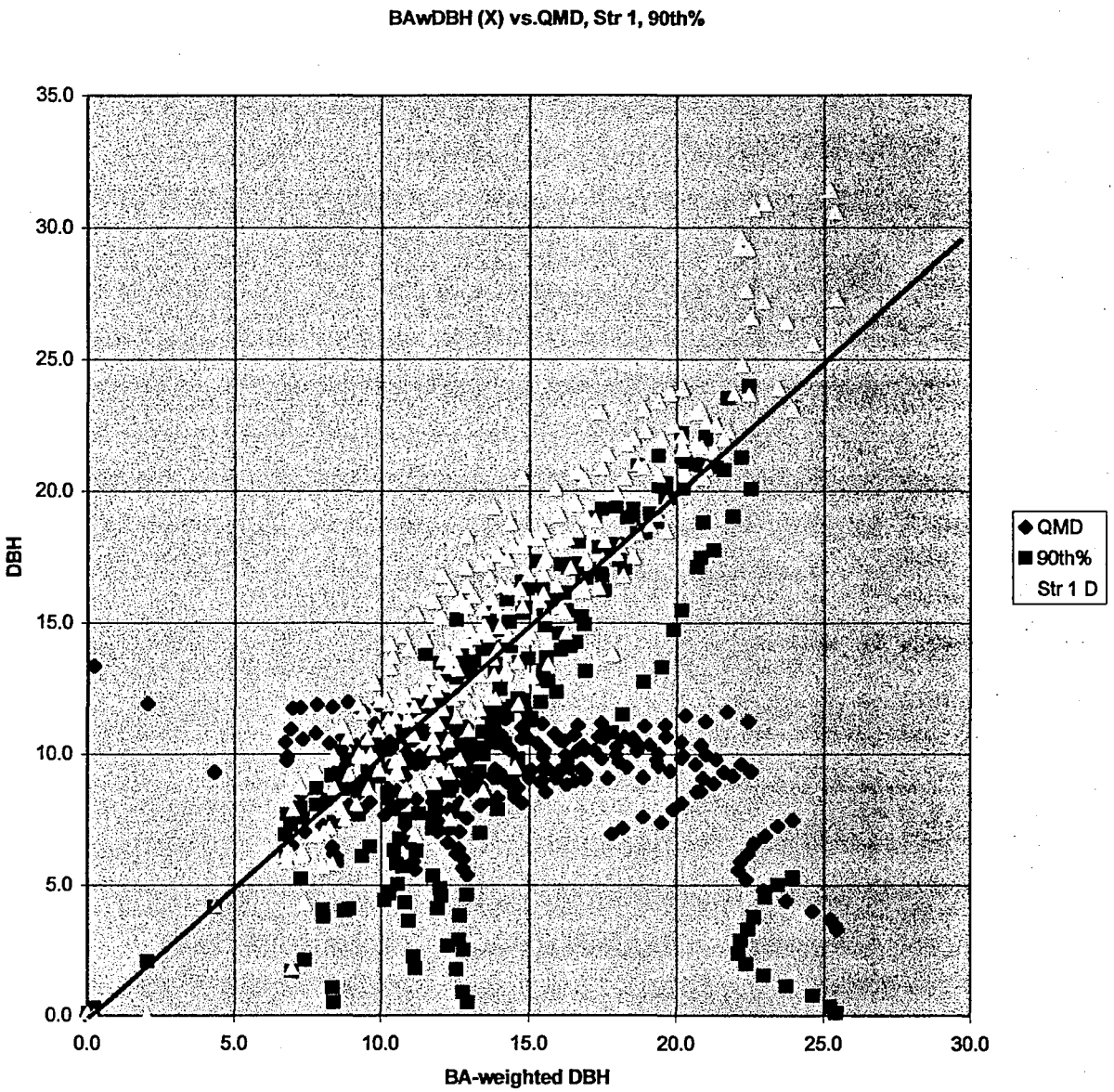


Figure C-2. Comparison of four stand-size classifier variables for 18 BNF FIA/FVS plots. BA-weighted DBH and Strata 1 are the only two that are fairly good surrogates for representing stand development over time in lieu of age class. Outliers in the lower right are from Plot 401 which had 8,956 trees per acre for initial conditions! Outliers in the upper right are also from Plot 401.

Consideration of Other Size Class Variables

Past research has provided information about other Size Class variables that were not available from the BNF FIA dataset or FVS projection, or the Northern Region Stand Classifier. Considerable information is available for the diameter growth rates of Western Larch "crop trees" on different habitat types and for different site indexes (Schmidt and others 1976). These kinds of graphs and tables provide a solid basis for characterizing Size Classes to represent stages of stand development for even-aged stands. Hallin (1959) provided a lesser amount of similar information for Ponderosa and Jeffrey Pine in California. Meyer (1938, 1961) provided some similar, but less specific information for Ponderosa Pine. Lynch (1958) may have additional Ponderosa Pine information, but I have not located a copy of that publication yet. Arno, Simmerman and Keane (1985) characterized their Structural Stages by Age, Average Age of Dominant Trees, Basal Area, and Stand Age. Some of this information is listed in Table C-4.

"Table C-4.xls"

Further literature review would undoubtedly provide additional information that would be useful to firm up the foundation for assigning Size Class to stands for landscape generalization. Using the average diameter of Dominant Trees has been suggested as a desirable Size Class variable (USFS-R1 2003, Pfister 2003, Pfister and others 2003). However, concerns have been raised about the arbitrary nature of assigning dominance classes and the possible inconsistencies among contributors to large inventory and stand exam databases. Top Height (the average height of the 40 largest trees per acre) has also been suggested as a possible non-arbitrary approach. The "Top Diameter" could easily be calculated for the same trees used to determine Top Height. Both of these approaches should be evaluated for their potential utility in assigning Size Class consistently that should also agree more closely with research results such as found in Schmidt and others (1976). Furthermore, these approaches would be easily applied in the field to make the Size Class call while visiting the stand.

Recognition and Communication of the Size Classification Problems

Although considerable progress is being made toward standardization of existing vegetation classification, implementation of standards requires understanding the complexity of certain classification concepts. Forest Survey has been continually working toward standardization of classification of FIA data for standardized reporting locally, by States, and nationally. Current FIA national standards and computer algorithms have been documented to place their plot data in size classes (Arner and others 2003). However, the FIA standards do not seem to be of much interest for other silvicultural and ecological applications where Size Class is used to represent stands moving through stand development stages rather than to summarize inventory volumes. National Forest Systems have recently completed standards for the classification of existing vegetation to meet agency management needs (Brohman and Bryant 2004). Standard size class breaks of 0,5,10,15,20, and 25 inches are recommended. Although

Table C - 3 – Number of decades in size classes (3 methods) for the first 24 stands in the Bitterroot/FVS database. (from Appendix C-2)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	PLOT #	HTG	FOR T	SIM CT	BAw/D	SIZ-SIM	DEC/	EST D	MBF		D 90%	S 90%	DEC	EST D	MBF		Str1	Siz	DEC	EstD	MBF
2	**161304900331**	**C1**	**ES**	**DF-ES**	**7.0**	P	**4+**	**7**	**156**		**1.7**	SS	**3+**	**5**	**156**		**1.8**	**SS**	**2+**	**3**	**156**
3											**5.9**	P	3	3	1856		**7.0**	P	2	2	1856
4					**9.2**	M	6	6	3525								**10.0**	M	2	2	3525
5											**10.9**	M	3	3	9791		**15.3**	L	7	7	9791
6											**14.0**	L	5+	8	23791						
7					**14.8**	L	4+	8	27840												
8	*END 331*	*C1*	*ES*	*DF-ES*	***17.4***				*40015*		***17.0***				*40015*		***23.0***	*VL*	*1*		*40015*
9																					
10	**IC 362**	**B2**	**DF**	**DF**	**11.8**	**M**	**3+**	**5**	**8202**		**7.9**	**P**	**2+**	**4**	**8202**		**11.3**	**M**	**2+**	**3**	**8202**
11											**11.6**	M	3	3	14097		**14.5**	L	5	5	14097
12					**14.8**	L	11	11	17869												
13											**15.5**	L	7	7	26137		**21.4**	VL	7		33039
14											**21.3**	VL	2		51242						
15	END 362				**20.7**				53703		**21.0**				53703		**21.8**				53703
16																					
17	**IC 363**	**B1**	**none**	**none**			**3**	**3**	**0**		**0.1**	**SS**	**4**	**4**	**0**		**0.1**	**SS**	**4**	**4**	**0**
18			DF	DF	**0.2**	SS	1	1													
19					**6.8**	P	2	2	408		**7.7**	P	2	2	408		**6.3**	P	2	2	408
20					**9.8**	M	3	3	3866		**10.5**	M	3	3	3866		**9.8**	M	2	2	3866
21					**14.1**	L	5+	8	15692		**14.7**	L	5+	7	15692		**14.4**	L	5	5	10734
22	*END 363*	*B1*	*DF*	*DF*					*35258*						*35258*		***22.0***	*VL*	*1*		*35258*
23																					
24	**IC 364**	**B1**	**DF**	**DF**	**24.0**	**VL**	**14**		**12977**		**29.7**	**VL**	**3**		**12977**		**15.3**	**L**	**1**		**12977**
25											**14.8**	L	5	5	18315		**25.2**	VL	13		14112
26											**21.3**	VL	1	1	29270						
27											**20.5**	L	1	1	31352						
28											**21.8**	VL	4		33066						
29	*END 364*				***30.5***				*38233*		***22.5***				*38233*		***31.1***				*38233*
30																					
31	**IC 365**	**F1**	[redacted]	**LP-AF**	**11.2**	**M**	**14**		**4620**		**1.8**	**SS**	**4+**	**4**	**4620**		**6.9**	**P**	**1+**	**2**	**4620**
32			AF	AF													**10.7**	M	2	2	4638
33																	**8.6**	P	1	1	8349
34											**5.0**	P	7	7	9590		**9.3**	M	4	4	9590
35											**9.0**	M	3+	6	19054		**8.7**	P	6+	?	13758
36	*END 365*		*AF*	*AF*	***13.5***				*22447*		***10.8***				*22447*		***8.6***				***22447***

Table C - 3 -- Number of decades in size classes (3 methods) for the first 24 stands in the Bitterroot/FVS database. (from Appendix C-2)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
37	PLOT #	HTG	FOR T	SIM CT	BAw/D	SIZ-SIM	DEC/	EST D	MBF		D 90%	S 90%	DEC	EST D	MBF		Str1	Siz	DEC	EstD	MBF
38	**IC 366**	**B2**	**DF**	**DF**	**17.8**	**L**	**9+**	**18**	**7311**		**10.8**	**M**	**4+**	**5**	**7311**		**13.8**	**M**	**1+**	**3**	**7311**
39											**14.7**	L	8	8	13977		**16.8**	L	2	2	8038
40					**21.3**	VL	5		24823								**22.0**	VL	11		11996
41											**21.3**	VL	1		33947						
42	*END 366*	*B2*	*DF*	*DF*	***22.5***				*36838*		***20.1***	*L*			*36838*		***26.6***				*36838*
43																					
44	**IC 397**	**C2**	**GF**	**GF**	**12.8**	**M**	**6+**	**18**	**13235**		**2.5**	**SS**	**4+**	**6**	**13235**		**12.3**	**M**	**1+**	**3**	**13235**
45											**7.0**	P	2	2	26787		**14.3**	L	13+	16	15166
46					**14.7**	L	8+	12	35584		**9.8**	M	3	3	35584						
47											**15.2**	L	5+	7	50589						
48	*END 397*	*C2*	*GF*	*GF*	***19.3***				*69325*		***18.8***				*69325*		***19.1***				*69325*
49																					
50	**IC 398**	**C2**	**DF**	**DF**	**11.9**	**M**	**4+**	**10**	**2418**		**10.9**	**M**	**6+**	**7**	**2418**		**10.9**	**M**	**2+**	**4**	**2418**
51					**14.0**	L	9	9	9269								**14.3**	L	8	8	4645
52											**15.5**	L	4	5	14878						
53											**21.0**	VL	4		28689		**21.0**	VL	4		28689
54					**21.0**	VL	1		37394												
55	*END 398*	*C2*	*DF*	*DF*	***21.0***				*37394*		***22.2***				*37394*		***22.6***				*37394*
56																					
57	**IC 400**	**B1**	**DF**	**DF**	**16.8**	**L**	**8+**	**14**	**21116**		**19.9**	**L**	**6+**	**?**	**21116**		**17.1**	**L**	**5+**	**8**	**21116**
58											**21.2**	VL	1		30674		**21.5**	VL	9		28568
59											**20.9**	L	1		32657						
60											**22.3**	VL	6		34307						
61					**21.5**	VL	6		34307												
62	*END 400*				***24.4***				*42167*		***23.4***				*42167*		***28.2***				*42167*
63																					
64	**IC 401**	**B2**	**PP**	**PP-DF**	**25.5**	**VL**	**14**		**27553**		**0.1**	**S**		**L**	**27553**		**27.3**	**VL**	**14**		**27553**
65											**5.0**	**P**			44591						
66	*END 401*	*B2*	*DF*	*DF*	***24.0***				*46065*		***5.3***				*46065*		***23.1***				*46065*
67																					
68	**IC 402**	**C2**	**DF**	**DF**	**14.5**	**L**	**11+**	**12**	**21143**		**8.6**	**P**	**1+**	**4**	**21143**		**9.5**	**P**	**4**	**4**	**21143**
69											**9.6**	M	3	3	24427						
70											**14.2**	L	6	6	37953		**14.6**	L	8	8	37953
71					**21.0**	VL	3		65016		**21.1**	VL	4		62011		**22.3**	VL	2		68202
72	*END 402*	*C2*	*DF*	*DF*	***22.5***				*71740*		***24.0***				*71740*		***23.7***				*71740*
73																					
74	**IC 434**	**C2**	**DF**	**DF**	**18.0**	**L**	**6+**	**14**	**21199**		**17.8**	**L**	**5+**	**12**	**21199**		**19.8**	**L**	**5+**	**?**	**21199**
75											**21.4**	VL	9		32395		**21.8**	VL	9		32395
76					**21.5**	VL	8		34631												
77	*END 434*	*C2*	*DF*	*DF*	***25.2***				*48853*		***21.8***				*48853*		***28.5***				*48853*

Table C - 3 -- Number of decades in size classes (3 methods) for the first 24 stands in the Bitterroot/FVS database. (from Appendix C-2)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
78	PLOT #	HTG	FOR T	SIM CT	BAw/D	SIZ-SIM	DECA	EST D	MBF		D 90%	S 90%	DEC	EST D	MBF		Str1	Siz	DEC	EstD	MBF
79	**IC 435**	**B2**	**DF**	**DF**	**8.4**	**P**	**2+**	**8**	**4056**		**7.4**	**P**	**3+**	**5**	**4056**		**8.7**	**P**	**1+**	**3**	**4056**
80					**9.2**	M	9	9	6747								**11.0**	M	4	4	4726
81											**9.2**	M	5	5	8457		**14.0**	L	9+	15	11313
82											**15.1**	L	6+	11	16816						
83					**15.3**	L	3+	15	27405												
84	*END 435*	*B2*	*DF*	*DF*	***15.3***				*27405*		***17.3***				*27405*		***18.2***				*27405*
85																					
86	**IC 436**	**B2**	**DF**	**DF**	**13.9**	**M**	**1+**	**10**	**14495**		**13.0**	**M**	**1+**	**5**	**14495**		**12.1**	**M**	**2+**	**4**	**14495**
87					**14.2**	L	12	12	16638		**14.1**	L	11	11	16638		**14.0**	L	9	9	21161
88					**21.4**	VL	1		48688		**21.0**	VL	2		46496		**21.6**	VL	3		44387
89	*END 436*	*B2*	*DF*	*DF*	***21.4***				*48688*		***20.9***				*48688*		***22.5***				*48688*
90																					
91	**IC 438**	**F1**	**AF**	**DF-AF**	**12.9**	**M**	**13+**	**30**	**8449**		**0.8**	**SS**	**5**	**5**	**8449**		**11.8**	**M**	**1+**	**2**	**8449**
92											**5.3**	P	4	4	17665		**14.4**	L	1		9286
93											**9.4**	M	9+	19	27360		**11.4**	M	11	11	10636
94					**14.3**	L	1+	18	34770								**14.5**	L	1+		34770
95	*END 438*				***14.3***				*34770*		***11.5***				*34770*		***14.5***				*34770*
96																					
97	**IC 439**	**F1**	**AF**	**AF**	**11.9**	**M**	**7+**	**10**	**15842**		**4.1**	**SS**	**3+**	**5**	**15842**		**11.2**	**M**	**1+**	**2**	**15842**
98																	**15.2**	L	1		17742
99											**7.2**	P	2	2	22097		**9.3**	M	7	7	22097
100											**9.0**	M	5	5	28865						
101					**14.2**	L	7+	16	37357								**14.6**	L	5+	12	45164
102											**14.1**	L	1+	1	54168						
103											**13.1**	M	1+	1	57091						
104	*END 439*	*F1*	*AF*	*AF*	***16.9***	*L*			*57091*		***13.1***	*M*			*57091*		***17.4***				*57091*
105																					
106	**IC 469**	**C1**	**LP**	**LP**	**9.4**	**M**	**9**	**9**	**12248**		**6.1**	**P**	**3+**	**4**	**12248**		**9.9**	**M**	**7+**	**8**	**12248**
107											**9.6**	M	5	5	18533						
108											**14.9**	L	6+	12	32760		**14.4**	L	7+	11	30072
109					**14.3**	L	5+	11	34875												
110	*END 469*	*C1*	*LP*	*DF-LP*	***16.6***	*L*			*41192*		***17.0***	*L*			*41192*		***18.5***				*41192*
111																					
112	**IC 470**	**D3**	**ES**	**ES**	**22.0**	**VL**	**14**		**52351**		**5.4**				**52351**		**25.9**	**VL**	**14**		**52351**
113											**7.2**				54226						
114											**8.0**				57684						
115											**8.7**				61793						
116											**9.6**				65519						
117											**11.5**				81921						
118											**12.0**				85037						
119	*END 470*	*D3*	*ES*	*ES*	***27.6***	*VL*			*93559*						*93559*		***34.5***				*93559*

Table C - 3 -- Number of decades in size classes (3 methods) for the first 24 stands in the Bitterroot/FVS database. (from Appendix C-2)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
120	PLOT #	HTG	FOR T	SIM CT	BAw/D	SIZ-SIM	DEC/	EST D	MBF		D 90%	S 90%	DEC	EST D	MBF		Str1	Siz	DEC	EstD	MBF
121	**IC 471**	**B2**	**DF**	**DF**	**24.1**	VL	**14**		**24338**		**21.2**	VL	**14**		**24388**		**24.6**	VL	**14**		**24338**
122	*END 471*	*B2*	*DF*	*DF*	***30.8***	*VL*			*44911*		***24.6***	*VL*			*44911*		***31.7***				*44911*
123																					
124	**IC 472**	**B2**	**DF**	**DF**	**20.7**	L	**2+**		**31548**		**20.6**	L	**1+**		**31548**		**22.0**	VL	**14**		**31548**
125											**21.1**	VL	**13**		**32515**						
126					**21.5**	VL	**12**		**34184**												
127	*END 472*	***B2***	***DF***	***DF***	***27.0***				*47544*		***26.1***	*VL*			*47544*		***28.3***				*47544*
128																					
129	**1C 473**	**B3**	**DF**	**DF-LP**	**8.8**	P	**2+**		**6769**		**4.1**	**SS**	**2+**		**6769**		**7.5**	P	**1+**	**3**	**6769**
130					**9.2**	M	12	12	8781		**7.9**	**P**	**2**	**2**	8781		**9.2**	M	7	7	7809
131											**9.7**	**M**	**7**	**7**	10454						
132											**14.0**	**L**	**1**		16362		**14.0**	L	5+	11	15330
133	*END 473*	*B3*	*DF*	*DF-LP*	***13.9***	*M*			*19918*		***13.4***	***M***	**1**		*19918*		***15.6***				*19918*
134																					
135	**IC 474**	**F1**	**AF**	**AF**	**8.4**	**P**	**11+**		**1884**		**0.5**	**SS**	**3**	**3**	**1884**		**9.9**	**M**	**1**	**?**	**1884**
136											**5.2**	P	9	9	3216		**5.8**	P	9	9	7809
137					**9.2**	M	3+	12	12898												
138											**9.3**	M	2+		15998		***9.4***	*1+*			17354
139	*END 474*	*F1*	*AF*	*AF*	***9.9***	*M*			*17354*		***9.2***	*M*			*17354*		***9.4***				*17354*
140																					
141	**IC 502**	**F1**	**DF**	**DF**	**10.1**	**M**	**9+**	**12**	**10249**		**4.4**	**S**	**2+**	**1**	**10249**		**12.1**	**M**	**1+**	**3**	**10249**
142											**5.7**	**P**	**4**	**4**	13346		**14.2**	L	13+	16	11698
143											**9.6**	**M**	**6**	**6**	25989						
144					**14.4**	L	5+	10	37834												
145											**14.6**	**L**	**3**		47190						
146	*END 502*	*F1*	*DF*	*DF-LP*	***16.6***	*L*			*49907*						*49907*		***19.5***				*49907*
147																					
148	**IC5 503**	**C1**	**LP**	**LP**	**7.0**	**P**	**5+**	**9**	**5690**		**7.7**	**P**	**3+**	**8**	**5690**		**7.9**	**P**	**2+**	**5**	**33060**
149											**9.2**	M	9	9	34936		**9.3**	M	9	9	**33444**
150					**9.4**	M	8	8	36463								**15.6**	L	3+	5	40812
151											**14.3**	L	2+	?	42091						
152	*END 503*	*C1*	*LP*	*LP*	***14.4***	*L*	*1*	*?*	*43979*		***14.1***	*L*			*43979*		***18.8***				*43979*

Tab[redacted]— Diameter growth of dominant trees from literature.

	A	B	C	D	E	F	G	H	I	J
1	**Species**	**Productivity**	**Age:@ 5"**	**@ 10"**		**@ 15"**		**@ 20"**	**References**	
2	Ponderosa-Jeffrey Pine	SI 80 @ 100	32	51		76		111	Hallin, W. 1959	
3	Ponderosa-Jeffrey Pine	SI 70 @ 100	36	57		89		135	p. 32	
4		??								
5	Ponderosa Pine								Lynch, D. 1958	
6										
7	Western Larch	SI 70 @ 50	25	52		88		130	Schmidt, W. + 1976	
8	Western Larch	SI 60 @ 50	28	60		103		*154*	p. 56	
9	" Crop Trees" (D & CD?	SI 50 @ 50	30	70		125		*180*		
10										
11	WL Potential Diam. Grc	SI 70 @ 50	27	57		95		*135*	Schmidt, W. + 1976	
12		SI 60 @ 50	31	66		110		*155*	p. 79	
13										
14	Ponderosa Pine >0.6"	SI 80 @ 100	40	85		135		200	Meyer, W. 1961	
15	Ponderosa Pine >6.5"	SI 80 @ 100		70		135		200	Meyer, W. 1961	
16	Ponderosa Pine >11.5"	SI 80 @ 100				105		190	Meyer, W. 1961	
17	*(S.I. 80@100=51@50)*									
18										
19	All Species	Habitat Type	Shrub to Sap		Pole		Mature Seral		Arno, S. + 1985	
20		PSME/PHMA dry	0 to 6"		6 to 14"		12 to 24"			
21		age range	3 to 50 years		13 to 50yr		100 to 260 yr			
22										
23		PSME/PHMA moist	0 to 5"		6 to 12"		11 to 18"			
24		age range	3 to 45		55 to 90		90 to 250			
25										
26		PSME/VAGL, XETE	0 to 5"		6 to 10"		11 to 16"			
27		age range	4 to 32		39 to 90		100 to 230			
28										
29		ABLA/XETE. VAGL	0 to 5"		5 to 11"		10 to 15"			
30		age range	4 to 41		41 to 105		130 to 250			
31										
32		ABLA/XETE, VASC	0 to 4"		6 to 10"		8 to 14"			
33		age range	4 to 41		61 to 120		140 to 220			
34										
35		ABLA/MEFE warm	0 to 5"		6 to 12"		11 to 20"			
36		age range	3 to 33		54 to 80		97 to 260			
37										
38		ABLA/MEFE cold	0 to 5"		7 to 10"		11 to 14"			
39		age range	3 to 29		60 to 115		128 to 200			

this consensus is a logical first step, it will not provide uniformity unless standardized methods are used to place plots and stands in an appropriate size class.

Part of our problem is lack of recognition of the variety of stand structures that are created by natural stand development processes, disturbance events, and management manipulations. This awareness has long been recognized in silviculture textbooks, but is often forgotten when we get too ingrained in looking at the forest through even-aged stand development mentality. In the Northern Rocky Mountains and generally in the West, recognition of uneven aged stands, prescriptions, and management has received growing recognition among silviculturists. Effects of underburning, stand replacement, and mixed severity fires have also been recently well documented. Modeling of forest stand development is progressing from even-aged scenarios toward a variety of "variants" or "additions" that help represent a wider variety of disturbances.

In order to understand the problems, it may be helpful to develop some datasets that help illustrate these complexities and compare alternative ways of classifying forest conditions by a wide variety of classification variables. Then the proper variable can be selected as a standard for certain applications while recognizing the value of other variables for other purposes.

This can be illustrated by using textbook figures like the Figure C-3 from Daniel, Helms and Baker 1979, included here as Figure C-3. These kinds of figures have been used to help provide communication and visualization of a variety of different stand structures.

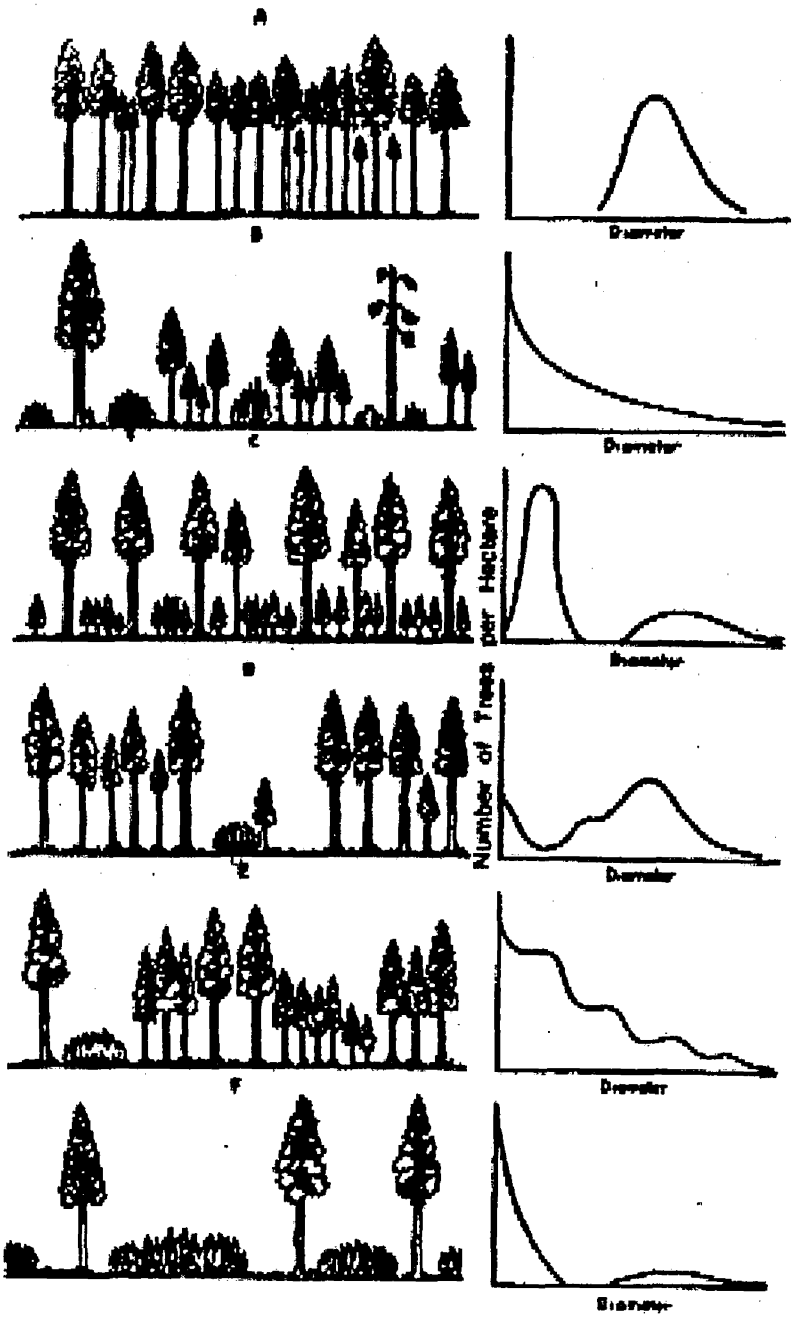


Figure 4-1 Characteristic appearances and stand graphs for even- and uneven-aged stands and some intermediate forms: A, even-aged; B, uneven-aged; C, storied; D, irregular, E, even-aged group; and F, reserve form. (From Baker, 1950.)

Figure C-3. Characteristic appearances and stand graphs for even- and uneven-aged stands and some intermediate forms: A. even-aged; C. storied; D. irregular, E. even-aged group; and F. reserve form. (From Baker 1950) (From Daniel, Helms, and Baker 1979, p. 44)

Using the general curve shapes displayed in Figure 3, I developed a set of hypothetical stand tables to approximate the curves shown in Figure C-3. Most of the stand tables were standardized to a total of 200 trees per acre. The approximated stand tables and accompanying figures are presented in Table C-5. Several stand Size Class variables were calculated for those stand tables to illustrate variability in accommodating a wide variety of characteristic stand structures found in nature or created through management.

"Table C-5.xls"

"Table C-5 (cont.).xls"

A summary table was prepared comparing the various Size Class variables (Table C-6). Comparisons can be made within each stand:

A) "Even-aged" -- most of the variables fell close to or within the 15 to 20" Size Class.

B1) "Uneven-aged Q1.4" -- QMD was very low, and BAwDBH was lower than the other ones.

B2) "Unven-aged Rx Q1.2" –QMD was very low, four fell within the 10-15" class, and FIA classification would probably be 15 to 20".

C) "Storied" – QMD was very low Top 40 and BAwDBH would fall in the 15 to 20" class while 90th % and FIA would be in 20-25" class.

D) "Irregular" – QMD was lowest (5 to 10" class), BAwDBH and FIA would fall in the 15-20" class, and Top 40 and 90th % would make a 20 to 25" class.

F) "Reserve" – 90th %, QMD, and Top 40 D were all very low and within the 5 to 10" class (all would classify the stand "Pole" even though there were very few trees in that class. BAwDBH and Top 40 QMD would fall in the 15 to 20" class (with very few trees actually in that class). FIA would likely fall in the 20 to 25 % class. This is the first example where Top 40 D and Top 40 QMD were very different from each other.

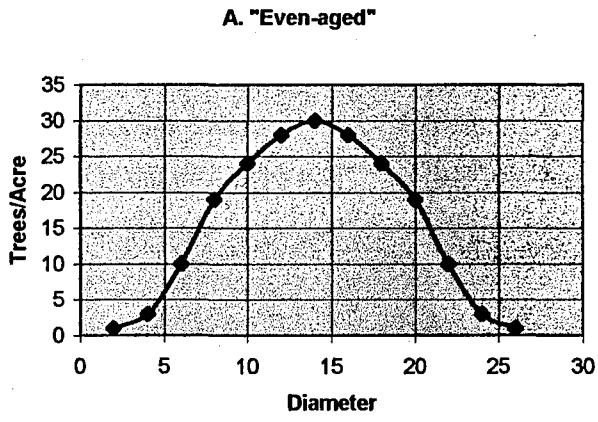
"Table C-6.xls"

Although we used a standard 200 trees per acres except for B1, it is obvious that the 90th percentile is not a good stand classifier because it varies greatly with stand density (total trees per acre). It would have been interesting to have Strata 1 DBH for comparison, but we would need to run these example stands in FVS.

Hopefully this illustration will generate interest in further exploration of the search for the "best" Size Class variable for specific application. Visualization and comparison of several alternatives will help lead the way toward standardization of more than one Size Class variable.

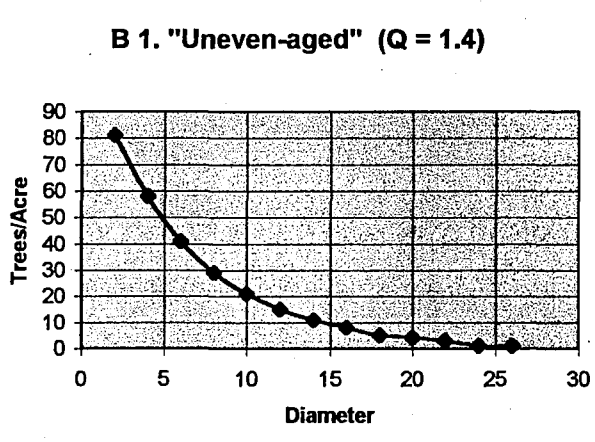
Table C-5. Characteristic stand tables for a variety of stand structures (adapted from Daniel, Helms, and Baker 1979, p. 44)

Diam.	# T/A.	BA	SumBA	Sum TD	QTD(BA)	BAwDBH
2	1	0.022	0.02			0.04
4	3	0.087	0.26			1.04
6	10	0.196	1.96			11.76
8	19	0.349	6.63			53.05
10	24	0.545	13.08			130.80
12	28	0.785	21.98			263.76
14	30	1.069	32.07			448.98
16	28	1.396	39.09			625.41
18	24	1.767	42.41	126	12.37	763.34
20	19	2.181	41.44	380	41.44	828.78
22	10	2.640	26.40	220	26.40	580.80
24	3	3.142	9.43	72	9.43	226.22
26	1	3.69	3.69	26	3.69	95.94
Totals	200		238.46	824	93.324	4029.93
QMD = 14.8			1.19		2.333	
Top D = 20.6		QTD = 20.7		20.6	20.7	
BAwDBH = 16.9						16.9



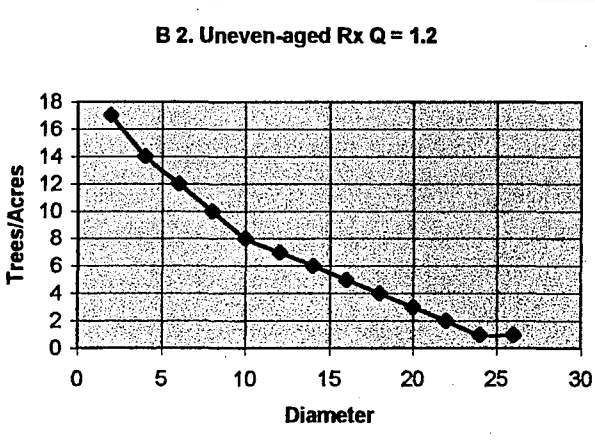
90% = 21	Top 20D = 21.9	Top 10D = 23.0
	FIA -->BA Stock. = 15-20" class	

Diam.	# T/A.	BA	SumBA	Sum TD	QTD(BA)	BAwDBH
2	81	0.022	1.78			3.56
4	58	0.087	5.05			20.18
6	41	0.196	8.04			48.22
8	29	0.349	10.12			80.97
10	21	0.545	11.45			114.45
12	15	0.785	11.78	84	5.50	141.30
14	11	1.069	11.76	154	11.76	164.63
16	8	1.396	11.17	128	11.17	178.69
18	5	1.767	8.84	90	8.84	159.03
20	4	2.181	8.72	80	8.72	174.48
22	3	2.640	7.92	66	7.92	174.24
24	1	3.142	3.14	24	3.14	75.41
26	1	3.69	3.69	26	3.69	95.94
Totals	278		103.44	652	60.733	1431.09
QMD = 8.3			0.372		1.518	
Top D = 16.3		QTD = 16.7		16.3	16.7	
BAwDBH = 13.8						13.8



90% = 15	Top 20D = 19.1	Top 10D = 21.4
	FIA-- > BA Stock. = 10-15" class	

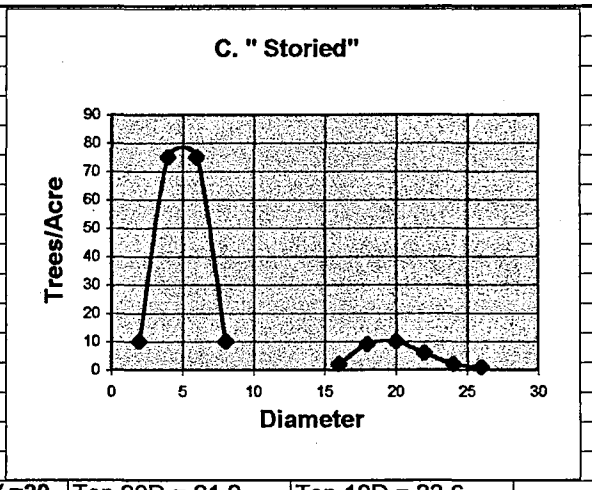
Diam.	# T/A.	BA	SumBA	Sum TD	QTD(BA)	BAwDBH
2	17	0.022	0.31			0.62
4	14	0.087	1.04			4.18
6	12	0.196	1.96			11.76
8	10	0.349	2.79	24	1.05	22.34
10	8	0.545	3.82	80	3.82	38.15
12	7	0.785	4.71	84	4.71	56.52
14	6	1.069	5.35	84	5.35	74.83
16	5	1.396	5.58	80	5.58	89.34
18	4	1.767	5.30	72	5.3	95.42
20	3	2.181	4.36	60	4.36	87.24
22	2	2.64	2.64	44	2.64	58.08
24	1	3.142	3.14	24	3.14	75.41
26	1	3.69	3.69	26	3.69	95.94
Totals	90		44.69	578	39.637	709.82
QMD = 9.5			0.497		0.991	
Top D = 14.5		QTD = 14.1		14.5	14.1	
BAwDBH = 15.9						15.9



90% = 14	Top 20D = 18.1	Top 10D = 20.8
	FIA-- >BA Stock. = 15-20" class	

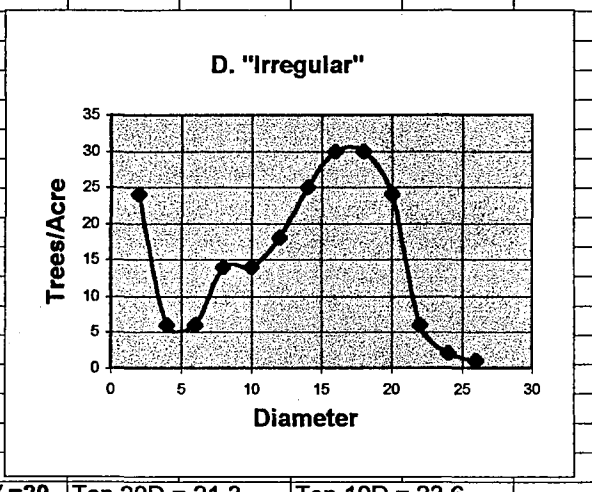
Table C-5 (cont.) -- Characteristic stand tables for a variety of stand structures (adapted from Daniel, Helms, and Baker 1979, p. 44)

Diam.	# T/A.	BA	SumBA	Sum TD	QTD(BA)	BAwDBH
2	10	0.022	0.22			0.44
4	75	0.087	6.53			26.10
6	75	0.196	14.70			88.20
8	10	0.349	3.49	80	3.49	27.92
16	2	1.396	2.79	32	2.79	44.67
18	9	1.767	15.90	162	15.90	286.25
20	10	2.181	**21.81**	200	21.81	436.20
22	6	2.640	**15.84**	132	15.84	348.48
24	2	3.142	**6.28**	48	6.28	150.82
26	1	3.69	3.69	26	3.69	95.94
Totals	200		91.25	680	69.809	1505.02
QMD = 9.2			**0.46**		1.74523	
Top D = 17.0		QTD = 17.9		**17**		
BAwDBH = 16.5						**16.5**



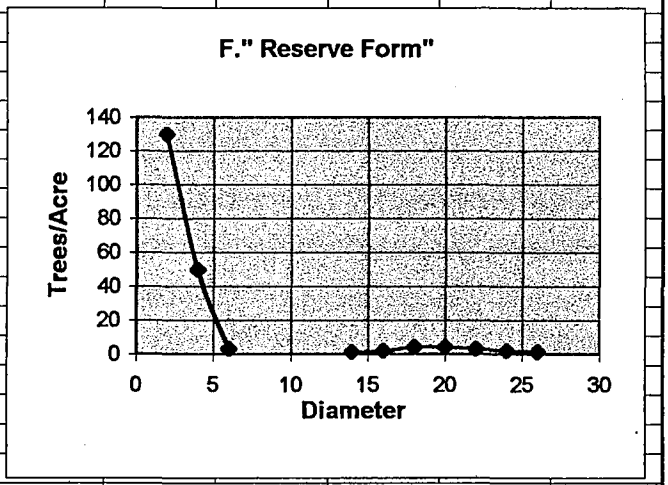
90%=20	Top 20D = 21.2	Top 10D = 22.6
	FIA-- > BA Stock. = 20-25" class	

Diam.	# T/A.	BA	SumBA	Sum TD	QTD(BA)	BAwDBH
2	24	0.022	0.53			1.06
4	6	0.087	0.52			2.09
6	6	0.196	1.18			7.06
8	14	0.349	4.89			39.09
10	14	0.545	7.63			76.30
12	18	0.785	14.13			169.56
14	25	1.069	26.73			374.15
16	30	1.396	**41.88**			670.08
18	30	1.767	**53.01**	126	12.37	954.18
20	24	2.181	**52.34**	480	52.34	1046.88
22	6	2.640	15.84	132	15.84	348.48
24	2	3.142	6.28	48	6.28	150.82
26	1	3.69	3.69	26	3.69	95.94
Totals	200		228.65	812	90.527	3935.67
QMD=14.5			**1.14**		2.26318	
Top D=20.3		QTD = 20.4		**20.3**		
BAwDBH = 17.2						**17.2**



90%=20	Top 20D = 21.3	Top 10D = 22.6
	FIA -- >BA Stock. = 15-20" class	

Diam.	# T/A.	BA	SumBA	Sum TD	QTD(BA)	BAwDBH
2	130	0.022	2.86			5.72
4	50	0.087	4.35			17.40
6	3	0.196	0.59	18	1.37	3.53
14	1	1.069	1.07	14	7.48	14.97
16	2	1.396	2.79	32	9.77	44.67
18	4	1.767	7.07	72	12.37	127.22
20	4	2.181	**8.72**	80	8.72	174.48
22	3	2.640	**7.92**	66	7.92	174.24
24	2	3.142	**6.28**	48	6.28	150.82
26	1	3.69	3.69	26	3.69	95.94
Totals	200		45.35	356	57.614	808.99
QMD=6.5			**0.23**		1.44035	
Top D=8.9		QTD = 16.3		**8.9**		
BAwDBH = 17.8						**17.8**



90% = 5	Top 20D = 17.2	Top 10D = 22.0
	FIA -- >BA Stock. = 20-25" class	

Table C - 6. Summary of Size-Class calls for variety of stand structures in Table C-5.

Stand Structure	QMD	Top 40 D	Top 40 QMD	BAwDBH	90th Percentile	FIA by BA Stock.
A. "Even-aged"	14.8	20.6	20.7	16.9	21	15 - 20 class
B1. "Uneven-aged"	8.3	16.3	16.7	13.8	15	10 - 15 class
(Q = 1.4)						
B2. "Uneven-aged"	9.5	12.8	14.1	13.8	14	15 - 20 class
(Rx of Q = 1.2						
C. "Storied"	9.2	17.0	17.9	16.5	20	20 - 25 class
D. "Irregular"	14.5	20.3	20.4	17.2	20	15 - 20 class
F. "Reserve"	6.5	**8.9**	**16.3**	17.2	**5**	**20 - 25 class**

Summary and Conclusions

The Bitterroot National Forest FIA database was a useful complement to several tasks in this RJVA, but was inadequate to appropriately test the Pathways in SIMPPLLE at this time. Too many problems prevented any conclusions regarding the accuracy and appropriateness of current Pathway parameters. However, the exercise provided the opportunity to address the original questions and raise several other questions that need to be addressed.

1) Pathways for progression through size classes will be variable depending upon the operational standards used to assign size class (USFS-R1 2003).

2) One or more additional algorithms need to be written to provide additional output from inventory data and FVS projections for comparison purposes in order to establish recommended standards for size class assignment. DESCRIBE should be reviewed and updated to provide an improved classifier for FIA and FVS databases.

3) Special rules are likely needed for stands where the large tree component is a minor part of the stand.

4) Uneven-age and true multi-story stands may require a special set of size classes.

5) The Northern Region Vegetation Council has made considerable progress and should be encouraged to continue to explore and improve standard algorithms.

6) We need to work with Growth and Yield specialists to enlist their help in providing additional output variables of interest for comparison purposes.

7) Stand tables and graphics should be used to characterize/describe stands for improved communication and educational purposes.

8) Simple variables are needed for stand size classification that can be used while in the field to classify a stand.

9) We need to demonstrate the relationship between field classification procedures and analytical output variables. Both are needed! Relationships among them need to be understood to build confidence in the use of both.

10) Most of these problems have been discussed by the Northern Region Vegetation Council (USFS-R1 2003) and some progress has been made (USFS-R1 2005). Additional discussion and formal suggestions have been made a previous BEMRP RJVA (Pfister and others 2003).

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Appendix C-2. Bitterroot National Forest FIA/FVS Size Classifications (first 24 of 226 forest stands.)

"App C-2 - BNF_FIA_FVS Sizes 1

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1	Setting ID	Cy	EI DT	EI-SIM	ForTy	Size	SZC	Size	SZCl	Ve	StrCl	T BA	TPA	*QMD*	BAw	DB	Cov	DEN	HTG	90th	SZ_C	TOT CU	MERC	MeBF	Str T D
2	161304900331	0	ES-DF	DF-ES	ES	5.0-	POL	5.0-	POLI	1	POLE	13.7	976	*1.6*	6.9		18	2	C1	1.7	SS	150	45	156	1.6
3	161304900331	1	ES-DF	DF-ES	ES	5.0-	POL	5.0-	POLI	1	POLE	19.8	918	*2.0*	7.4		24	2	C1	2.1	SS	234	70	156	4.3
4	161304900331	2	ES-GF	ES	ES	5.0-	POL	5.0-	POLI	C	PMS	39	816	*3.0*	8.1		40	3	C1	3.8	SS	499	199	735	7.0
5	161304900331	3	ES	ES	ES	5.0-	POL	5.0-	POLI	C	PMS	69.5	836	*3.9*	8.5		56	3	C1	5.9	POL	997	506	1856	8.1
6	161304900331	4	ES	ES	ES	5.0-	POL	9.0-	MED	C	MMS	111	773	*5.1*	9.3		67	3	C1	7.7	POL	1781	924	3525	10.0
7	161304900331	5	ES	ES	ES	10.0	MEI	9.0-	MED	C	MMS	158	825	*5.9*	10.4		74	4	C1	7.9	POL	2829	1621	7228	13.7
8	161304900331	6	ES	ES	ES	10.0	MEI	9.0-	MED	2	MTS	195	727	*7.0*	11.2		76	4	C1	10.9	MED	3788	2370	9791	15.3
9	161304900331	7	ES	ES	ES	10.0	MEI	9.0-	MED	C	MMS	223	715	*7.6*	12.1		77	4	C1	11.6	MED	4658	3049	13464	16.8
10	161304900331	8	ES	ES	ES	10.0	MEI	9.0-	MED	C	MMS	244	611	*8.6*	12.9		77	4	C1	13.2	MED	5444	4074	19555	18.3
11	161304900331	9	ES	ES	ES	10.0	MEI	9.0-	MED	1	MED	262	647	*8.6*	13.8		76	4	C1	14.0	MED	6228	4900	23791	19.4
12	161304900331	10	ES	ES	ES	10.0	MEI	14.0	LAR	C	LMS	278	533	*9.8*	14.8		75	4	C1	15.4	LAR	7026	5773	27840	20.5
13	161304900331	11	ES	ES	ES	15.0	LAR	14.0	LAR	C	LMS	288	526	*10.0*	15.9		74	4	C1	15.9	LAR	7717	6487	32647	20.1
14	161304900331	12	ES	ES	ES	15.0	LAR	14.0	LAR	C	LMS	295	435	*11.2*	16.7		72	4	C1	18.1	LAR	8292	7084	36504	20.7
15	161304900331	13	ES	ES	ES	15.0	LAR	14.0	LAR	C	LMS	300	472	*10.8*	17.4		71	4	C1	17.0	LAR	8826	7673	40015	23.0
16														*###*											
17	161304900362	0	DF	DF	DF	10.0	MEI	9.0-	MED	C	MMS	73.4	1002	*3.7*	11.8		38	2	B2	7.9	POL	1917	1656	8202	11.3
18	161304900362	1	DF	DF	DF	10.0	MEI	9.0-	MED	C	MMS	86	909	*4.2*	12.4		41	3	B2	8.8	POL	2319	2001	10362	13.6
19	161304900362	2	DF	DF	DF	10.0	MEI	9.0-	MED	2	MTS	107	746	*5.1*	13.6		46	3	B2	11.6	MED	3110	2716	14097	14.5
20	161304900362	3	DF	DF	DF	10.0	MEI	14.0	LAR	2	LTS	128	829	*5.3*	14.8		54	3	B2	12.0	MED	3948	3411	17869	15.6
21	161304900362	4	DF	DF	DF	15.0	LAR	14.0	LAR	C	LMS	147	687	*6.3*	15.6		59	3	B2	13.7	MED	4707	4085	22078	17.5
22	161304900362	5	DF	DF	DF	15.0	LAR	14.0	LAR	C	LMS	164	625	*6.9*	16.3		63	3	B2	15.5	LAR	5440	4742	26137	18.2
23	161304900362	6	DF	DF	DF	15.0	LAR	14.0	LAR	2	LTS	179	528	*7.9*	16.9		66	3	B2	16.7	LAR	6088	5261	29488	19.0
24	161304900362	7	DF	DF	DF	15.0	LAR	14.0	LAR	2	LTS	192	555	*8.0*	17.3		67	3	B2	17.8	LAR	6737	5852	33039	21.4
25	161304900362	8	DF	DF	DF	15.0	LAR	14.0	LAR	2	LTS	203	459	*9.0*	18.3		68	3	B2	19.0	LAR	7320	6321	36420	21.8
26	161304900362	9	DF	DF	DF	15.0	LAR	14.0	LAR	2	LTS	213	539	*8.5*	18.9		68	3	B2	18.6	LAR	7843	6686	39068	23.1
27	161304900362	10	DF	DF	DF	15.0	LAR	14.0	LAR	2	LTS	223	440	*9.6*	19.4		69	3	B2	20.4	LAR	8372	7241	43005	
28	161304900362	11	DF	DF	DF	15.0	LAR	14.0	LAR	2	LTS	233	477	*9.5*	19.9		70	4	B2	17.2	LAR	8891	7954	47443	
29	161304900362	12	DF	DF	DF	20.0	V-L	14.0	LAR	2	LTS	242	390	*10.7*	20.4		71	4	B2		V-LA	9372	8439	51242	
30	161304900362	13	DF	DF	DF	20.0	V-L	14.0	LAR	2	LTS	250	422	*10.4*	20.9		71	4	B2		V-LA	9833	8896	53703	
31														*###*											

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
32	161304900363	0	none	none	none	non	non	non	none	nor	###	0	60	0.0	0.0		0	1	B1	0.1	SS	0	0	0	0.1
33	161304900363	1	none	none	none	non	non	non	none	nor	###	0.02	56	0.2	0.2		1	1	B1	0.3	SS	0	0	0	0.0
34	161304900363	2	none	none	none	non	non	non	none	nor	###	0.68	50	1.6	2.0		4	1	B1	2.1	SS	6	0	0	0.0
35	161304900363	3	DF	DF	DF	0.1-	SS	1.0-	SS	1	SS	3.56	154	2.1	4.3		9	1	B1	4.2	SS	50	0	0	4.2
36	161304900363	4	DF	DF	DF	5.0-	POL	5.0-	POL	1	POLE	10	138	3.6	6.8		16	2	B1	7.7	POL	185	93	408	6.3
37	161304900363	5	DF	DF	DF	5.0-	POL	5.0-	POL	C	PMS	23.3	179	4.9	8.7		27	2	B1	8.8	POL	510	348	1781	7.9
38	161304900363	6	DF	DF	DF	5.0-	POL	9.0-	MED	C	MMS	39.9	166	6.6	9.8		37	2	B1	10.5	MED	951	727	3866	9.8
39	161304900363	7	DF	DF	DF	10.0	MED	9.0-	MED	C	MMS	60.5	248	6.7	11.1		45	3	B1	11.8	MED	1572	1290	6752	11.8
40	161304900363	8	DF	DF	DF	10.0	MED	9.0-	MED	1	MED	84	221	8.4	12.7		52	3	B1	13.7	MED	2411	2067	10734	14.4
41	161304900363	9	DF	DF	DF	10.0	MED	14.0	LARG	1	LARG	107	252	8.8	14.3		57	3	B1	14.7	MED	3315	2936	15692	16.4
42	161304900363	10	DF	DF	DF	15.0	LAR	14.0	LARG	1	LARG	130	218	10.5	15.4		61	3	B1	16.4	LAR	4293	3871	21002	17.3
43	161304900363	11	DF	DF	DF	15.0	LAR	14.0	LARG	1	LARG	150	257	10.4	16.5		64	3	B1	17.2	LAR	5180	4688	25810	19.6
44	161304900363	12	DF	DF	DF	15.0	LAR	14.0	LARG	1	LARG	167	217	11.9	17.5		65	3	B1	19.3	LAR	5955	5378	29909	20.9
45	161304900363	13	DF	DF	DF	15.0	LAR	14.0	LARG	1	LARG	183	274	11.1	18.5		67	3	B1	19.3	LAR	6771	6201	35258	22.0
46														###											
47	161304900364	0	DF	DF	DF	20.0	V-L	21.0	V-LA	2	VLTS	80	48	17.5	24.1		34	2	B1	29.7	V-LA	2457	2224	12977	15.3
48	161304900364	1	DF	DF	DF	20.0	V-L	21.0	V-LA	2	VLTS	84.8	47	18.1	24.2		35	2	B1	30.2	V-LA	2639	2403	14112	25.2
49	161304900364	2	DF	DF	DF	20.0	V-L	21.0	V-LA	2	VLTS	93.8	46	19.3	24.6		37	2	B1	30.8	V-LA	3018	2744	16151	22.4
50	161304900364	3	DF	DF	DF	25.0	XX-	21.0	V-LA	2	VLTS	102	281	8.2	25.1		39	2	B1	14.8	MED	3390	3092	18315	20.2
51	161304900364	4	DF	DF	DF	25.0	XX-	21.0	V-LA	2	VLTS	109	230	9.3	25.7		40	3	B1	16.7	LAR	3751	3424	20401	20.5
52	161304900364	5	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAR	116	266	8.9	26.3		41	3	B1	16.8	LAR	4078	3742	22561	22.4
53	161304900364	6	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAR	122	218	10.1	26.9		43	3	B1	18.4	LAR	4408	4043	24727	23.8
54	161304900364	7	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAR	129	255	9.7	27.5		44	3	B1	19.2	LAR	4788	4395	27163	25.4
55	161304900364	8	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAR	136	210	10.9	28.1		46	3	B1	21.3	V-LA	5120	4703	29270	26.7
56	161304900364	9	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAR	141	290	9.4	28.5		47	3	B1	20.5	LAR	5406	4980	31352	26.9
57	161304900364	10	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAR	146	239	10.6	29.1		48	3	B1	21.8	V-LA	5685	5228	33066	27.9
58	161304900364	11	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAR	151	313	9.4	29.5		48	3	B1	21.8	V-LA	5951	5446	34777	28.9
59	161304900364	12	DF	DF	DF	25.0	XX-	21.0	V-LA	2	VLTS	155	255	10.5	30.1		49	3	B1	22.1	V-LA	6184	5659	36461	30.1
60	161304900364	13	DF	DF	DF	25.0	XX-	21.0	V-LA	2	VLTS	159	277	10.2	30.1		50	3	B1	22.1	V-LA	6416	5882	38233	30.1
61														###											

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
62	161304900365	0	AF-LP	LP-AF	AF	10.0	MEI	9.0-	MEI	C	MMS	63.6	3229	*1.9*	11.2		37	2	F1	1.8	SS	1286	943	4620	6.9
63	161304900365	1	AF	AF	AF	10.0	MEI	9.0-	MEI	C	MMS	71.2	2931	*2.1*	11.1		40	3	F1	2.3	SS	1461	1029	4638	10.7
64	161304900365	2	AF	AF	AF	10.0	MEI	9.0-	MEI	C	MMS	90.7	2411	*2.6*	11.0		50	3	F1	3.6	SS	1894	1389	6328	11.3
65	161304900365	3	AF	AF	AF	10.0	MEI	9.0-	MEI	C	MMS	112	2111	*3.1*	10.8		59	3	F1	4.3	SS	2377	1709	8349	8.6
66	161304900365	4	AF	AF	AF	10.0	MEI	9.0-	MEI	C	MMS	136	1772	*3.7*	10.6		64	3	F1	5.0	POL	2886	1971	9590	9.3
67	161304900365	5	AF	AF	AF	10.0	MEI	9.0-	MEI	2	MTS	154	1543	*4.3*	10.5		67	3	F1	5.8	POL	3306	2171	10531	9.4
68	161304900365	6	AF	AF	AF	10.0	MEI	9.0-	MEI	C	MMS	172	1269	*5.0*	10.5		67	3	F1	6.3	POL	3677	2338	11608	9.7
69	161304900365	7	AF	AF	AF	10.0	MEI	9.0-	MEI	C	MMS	183	1183	*5.3*	10.7		67	3	F1	6.8	POL	3993	2482	12488	9.8
70	161304900365	8	AF	AF	AF	10.0	MEI	9.0-	MEI	C	MMS	191	982	*6.0*	10.8		66	3	F1	7.5	POL	4248	2670	13758	8.7
71	161304900365	9	AF	AF	AF	10.0	MEI	9.0-	MEI	C	MMS	194	967	*6.1*	11.3		64	3	F1	7.7	POL	4484	2945	15116	8.9
72	161304900365	10	AF	AF	AF	10.0	MEI	9.0-	MEI	C	MMS	197	787	*6.8*	11.8		61	3	F1	8.4	POL	4740	3330	17114	8.9
73	161304900365	11	AF	AF	AF	10.0	MEI	9.0-	MEI	C	MMS	200	793	*6.8*	12.4		60	3	F1	9.0	MEI	5014	3676	19054	7.5
74	161304900365	12	AF	AF	AF	10.0	MEI	9.0-	MEI	1	MED	203	658	*7.5*	12.9		58	3	F1	10.0	MEI	5291	4127	21341	8.1
75	161304900365	13	AF	AF	AF	10.0	MEI	9.0-	MEI	C	MMS	205	691	*7.4*	13.4		57	3	F1	10.5	MEI	5551	4395	22447	8.6
76														*###*											
77	161304900366	0	DF	DF	DF	15.0	LAR	14.0	LAR	2	LTS	56.1	468	*4.7*	17.8		30	2	B2	10.8	MEI	1537	1380	7311	13.8
78	161304900366	1	DF	DF	DF	15.0	LAR	14.0	LAR	2	LTS	60.7	429	*5.1*	18.2		31	2	B2	11.5	MEI	1696	1527	8038	16.8
79	161304900366	2	DF	DF	DF	15.0	LAR	14.0	LAR	2	LTS	70.1	364	*5.9*	18.9		35	2	B2	12.7	MEI	2029	1834	10146	20.9
80	161304900366	3	DF	DF	DF	15.0	LAR	14.0	LAR	2	LTS	80.1	435	*5.8*	19.5		40	3	B2	13.3	MEI	2387	2156	11996	22.0
81	161304900366	4	DF	DF	DF	15.0	LAR	14.0	LAR	3	LMS	91.2	368	*6.7*	19.9		45	3	B2	14.7	MEI	2768	2482	13977	22.5
82	161304900366	5	DF	DF	DF	20.0	V-L	14.0	LAR	3	LMS	102	351	*7.3*	20.2		49	3	B2	15.5	LAR	3124	2789	15835	22.1
83	161304900366	6	DF	DF	DF	20.0	V-L	14.0	LAR	2	LTS	114	305	*8.3*	20.7		52	3	B2	17.1	LAR	3591	3151	18052	23.0
84	161304900366	7	DF	DF	DF	20.0	V-L	14.0	LAR	2	LTS	126	327	*8.4*	20.8		56	3	B2	17.5	LAR	3979	3464	20123	23.1
85	161304900366	8	DF	DF	DF	20.0	V-L	14.0	LAR	2	LTS	140	289	*9.4*	20.7		59	3	B2	18.5	LAR	4436	3781	22188	20.5
86	161304900366	9	DF	DF	DF	20.0	V-L	21.0	V-LA	2	VLTS	152	332	*9.2*	20.1		61	3	B2	17.6	LAR	4893	4175	24823	21.5
87	161304900366	10	DF	DF	DF	20.0	V-L	21.0	V-LA	2	VLTS	164	287	*10.2*	21.1		63	3	B2	20.4	LAR	5352	4659	28125	22.0
88	161304900366	11	DF	DF	DF	20.0	V-L	21.0	V-LA	2	VLTS	177	321	*10.1*	21.1		65	3	B2	19.4	LAR	5865	5200	31425	22.1
89	161304900366	12	DF	DF	DF	20.0	V-L	21.0	V-LA	2	VLTS	189	277	*11.2*	21.1		66	3	B2	21.1	V-LA	6351	5694	33947	22.1
90	161304900366	13	DF	DF	DF	20.0	V-L	21.0	V-LA	2	VLTS	198	317	*10.7*	21.1		67	3	B2	22.8	LAR	6743	6104	36838	22.1
91														*###*											

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
92	161304900397	0	GF-PP	GF	GF	10.0	MEI	9.0-	MEI	2	MTS	109	3182	2.5	12.8		64	3	C2	2.3	SS	2951	2390	13235	12.3
93	161304900397	1	GF-PP	GF	GF	10.0	MEI	9.0-	MEI	2	MTS	123	2861	2.8	12.6		68	3	C2	2.9	SS	3350	2711	15166	14.3
94	161304900397	2	GF-PP	GF	GF	10.0	MEI	9.0-	MEI	2	MTS	148	2324	3.4	12.7		73	4	C2	3.8	SS	4194	3320	18514	15.9
95	161304900397	3	GF-PP	GF	GF	10.0	MEI	9.0-	MEI	2	MTS	169	1920	4.0	12.9		76	4	C2	4.6	SS	5006	3923	22002	16.4
96	161304900397	4	GF-PP	GF	GF	10.0	MEI	9.0-	MEI	C	MMS	185	1528	4.7	13.4		76	4	C2	7.0	POL	5799	4726	26787	14.6
97	161304900397	5	GF-PP	GF	GF	10.0	MEI	9.0-	MEI	C	MMS	199	1298	5.3	14.0		76	4	C2	7.9	POL	6625	5438	31319	14.0
98	161304900397	6	GF-PP	GF	GF	10.0	MEI	14.0	LAR	C	LMS	209	1032	6.1	14.7		74	4	C2	9.8	MEI	7411	6134	35584	14.4
99	161304900397	7	GF-PP	GF	GF	15.0	LAR	14.0	LAR	2	LTS	218	882	6.7	15.4		73	4	C2	12.0	MEI	8207	6912	40188	15.8
100	161304900397	8	GF-PP	GF	GF	15.0	LAR	14.0	LAR	2	LTS	225	701	7.7	16.1		71	4	C2	13.9	MEI	8980	7687	45552	15.6
101	161304900397	9	GF-PP	GF	GF	15.0	LAR	14.0	LAR	C	LMS	232	644	8.1	16.8		69	3	C2	15.2	LAR	9734	8489	50589	16.5
102	161304900397	10	GF-PP	GF	GF	15.0	LAR	14.0	LAR	C	LMS	239	519	9.2	17.5		68	3	C2	16.8	LAR	10488	9234	55371	17.4
103	161304900397	11	GF-PP	GF	GF	15.0	LAR	14.0	LAR	C	LMS	243	522	9.2	18.0		67	3	C2	17.4	LAR	11113	9893	60181	17.9
104	161304900397	12	GF-PP	GF	GF	15.0	LAR	14.0	LAR	C	LMS	247	422	10.4	18.7		65	3	C2	18.4	LAR	11738	10564	64406	18.4
105	161304900397	13	GF-PP	GF	GF	15.0	LAR	14.0	LAR	C	LMS	251	455	10.1	19.3		64	3	C2	18.8	LAR	12340	11204	69325	19.1
106														###											
107	161304900398	0	DF	DF	DF	10.0	MEI	9.0-	MEI	2	MTS	35.1	338	4.4	11.9		28	2	C2	10.9	MEI	681	531	2418	12.4
108	161304900398	1	DF	DF	DF	10.0	MEI	9.0-	MEI	2	MTS	41.8	312	5.0	12.2		32	2	C2	11.6	MEI	833	659	3060	13.8
109	161304900398	2	DF	DF	DF	10.0	MEI	9.0-	MEI	C	MMS	57.5	268	6.3	12.9		41	3	C2	13.3	MEI	1201	965	4645	14.3
110	161304900398	3	DF	DF	DF	10.0	MEI	9.0-	MEI	C	MMS	76.5	481	5.4	13.5		49	3	C2	10.0	MEI	1643	1386	7000	14.9
111	161304900398	4	DF	DF	DF	10.0	MEI	14.0	LAR	C	LMS	97.3	411	6.6	14.0		56	3	C2	12.5	MEI	2134	1784	9269	14.8
112	161304900398	5	DF	DF	DF	10.0	MEI	14.0	LAR	C	LMS	118	432	7.1	14.2		61	3	C2	13.5	MEI	2689	2220	11864	15.3
113	161304900398	6	DF	DF	DF	15.0	LAR	14.0	LAR	C	LMS	138	370	8.3	15.4		65	3	C2	15.3	LAR	3287	2721	14878	15.8
114	161304900398	7	DF	DF	DF	15.0	LAR	14.0	LAR	C	LMS	158	410	8.4	16.3		67	3	C2	17.1	LAR	3899	3209	17826	16.2
115	161304900398	8	DF	DF	DF	15.0	LAR	14.0	LAR	C	LMS	176	348	9.6	17.1		69	3	C2	19.0	LAR	4473	3864	22065	16.9
116	161304900398	9	DF	DF	DF	15.0	LAR	14.0	LAR	C	LMS	190	370	9.7	17.8		70	4	C2	19.4	LAR	4989	4356	25152	16.9
117	161304900398	10	DF	DF	DF	15.0	LAR	14.0	LAR	C	LMS	204	311	11.0	18.2		71	4	C2	21.4	LAR	5495	4875	28689	17.0
118	161304900398	11	DF	DF	DF	15.0	LAR	14.0	LAR	C	LMS	215	352	10.6	18.5		71	4	C2	21.1	V-LA	5953	5354	31749	20.6
119	161304900398	12	DF	DF	DF	20.0	V-L	14.0	LAR	C	LMS	228	290	12.0	19.0		72	4	C2	22.1	V-LA	6414	5796	34512	21.5
120	161304900398	13	DF	DF	DF	20.0	V-L	21.0	V-LA	C	VLM	240	339	11.4	19.4		72	4	C2	22.1	V-LA	6866	6207	37394	21.4
121														###											

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
122	161304900400	0	DF	DF	DF	15.0	LAR	14.0	LARC		LMS	144	171	*12.4*	16.8		50	3	B1	19.9	LAR	4382	3845	21116	17.1
123	161304900400	1	DF	DF	DF	15.0	LAR	14.0	LARC		LMS	147	163	*12.9*	17.1		49	3	B1	20.3	LAR	4543	4008	21902	18.8
124	161304900400	2	DF	DF	DF	15.0	LAR	14.0	LARC		LMS	152	151	*13.6*	17.7		49	3	B1	20.9	LAR	4831	4258	23792	19.9
125	161304900400	3	DF	DF	DF	15.0	LAR	14.0	LARC		LMS	156	282	*10.1*	18.3		49	3	B1	18.8	LAR	5082	4510	25328	20.3
126	161304900400	4	DF	DF	DF	15.0	LAR	14.0	LARC		LMS	161	234	*11.2*	19.0		49	3	B1	19.7	LAR	5361	4785	27026	20.9
127	161304900400	5	DF	DF	DF	15.0	LAR	14.0	LARC		LMS	165	280	*10.4*	19.6		49	3	B1	19.7	LAR	5600	5034	28568	21.5
128	161304900400	6	DF	DF	DF	20.0	V-L	14.0	LARC		LMS	168	230	*11.6*	20.2		49	3	B1	21.2	V-LA	5848	5310	30674	22.1
129	161304900400	7	DF	DF	DF	20.0	V-L	14.0	LARC		LMS	172	270	*10.8*	20.9		49	3	B1	20.9	LAR	6092	5592	32657	23.0
130	161304900400	8	DF	DF	DF	20.0	V-L	21.0	V-LA	C	VLMS	177	220	*12.1*	21.5		49	3	B1	22.3	V-LA	6357	5849	34307	23.8
131	161304900400	9	DF	DF	DF	20.0	V-L	21.0	V-LA	C	VLMS	180	243	*11.7*	22.0		49	3	B1	22.5	V-LA	6584	6080	36001	25.6
132	161304900400	10	DF	DF	DF	20.0	V-L	21.0	V-LA	C	VLMS	183	196	*13.1*	22.6		49	3	B1	24.2	V-LA	6803	6304	37642	25.0
133	161304900400	11	DF	DF	DF	20.0	V-L	21.0	V-LA	C	VLMS	186	252	*11.6*	23.1		49	3	B1	22.9	V-LA	7001	6440	38684	26.1
134	161304900400	12	DF	DF	DF	20.0	V-L	21.0	V-LA	C	VLMS	189	198	*13.2*	23.7		49	3	B1	25.0	V-LA	7224	6692	40447	27.7
135	161304900400	13	DF	DF	DF	20.0	V-L	21.0	V-LA	C	VLMS	191	256	*11.7*	24.4		48	3	B1	23.4	V-LA	7441	6885	42167	28.2
136														###											
137	161304900401	0	PP-DF	PP-DF	PP	25.0	XX-	21.0	V-LA	2	VLTS	112	8956	*1.5*	25.5		48	3	B2	0.1	SS	4675	4269	27553	27.3
138	161304900401	1	PP-DF	PP-DF	PP	25.0	XX-	21.0	V-LA	2	VLTS	116	8087	*1.6*	25.4		49	3	B2	0.1	SS	4813	4374	28339	30.6
139	161304900401	2	PP-DF	PP-DF	PP	25.0	XX-	21.0	V-LA	2	VLTS	124	6575	*1.9*	25.2		56	3	B2	0.3	SS	5119	4720	30781	31.4
140	161304900401	3	DF-PP	PP-DF	DF	20.0	V-L	21.0	V-LA	2	VLTS	136	5395	*2.1*	24.6		68	3	B2	0.8	SS	5415	5006	32503	25.8
141	161304900401	4	DF-PP	PP-DF	DF	20.0	V-L	21.0	V-LA	3	VLMS	149	4400	*2.5*	23.7		75	4	B2	1.1	SS	5740	5275	34183	26.4
142	161304900401	5	DF-PP	PP-DF	DF	20.0	V-L	21.0	V-LA	3	VLMS	163	3631	*2.9*	23.0		80	4	B2	1.5	SS	6092	5558	35872	27.2
143	161304900401	6	DF-PP	PP-DF	DF	20.0	V-L	21.0	V-LA	2	VLTS	175	2971	*3.3*	22.4		82	4	B2	2.0	SS	6402	5781	37418	27.6
144	161304900401	7	DF	DF	DF	20.0	V-L	21.0	V-LA	3	VLMS	185	2451	*3.7*	22.1		83	4	B2	2.4	SS	6691	5992	38861	29.2
145	161304900401	8	DF	DF	DF	20.0	V-L	21.0	V-LA	3	VLMS	192	1975	*4.2*	21.8		82	4	B2	2.9	SS	6949	6187	40148	29.8
146	161304900401	9	DF	DF	DF	20.0	V-L	21.0	V-LA	3	VLMS	198	1646	*4.7*	21.3		81	4	B2	3.3	SS	7198	6401	41608	30.2
147	161304900401	10	DF	DF	DF	20.0	V-L	21.0	V-LA	2	VLTS	202	1302	*5.3*	21.0		79	4	B2	3.8	SS	7408	6578	42802	30.7
148	161304900401	11	DF	DF	DF	20.0	V-L	21.0	V-LA	3	VLTS	206	1068	*5.9*	20.8		77	4	B2	4.5	SS	7606	6676	43696	31.1
149	161304900401	12	DF	DF	DF	20.0	V-L	21.0	V-LA	3	VLMS	209	841	*6.7*	20.6		75	4	B2	5.3	POL	7800	6831	44591	31.5
150	161304900401	13	DF	DF	DF	20.0	V-L	21.0	V-LA	3	VLMS	210	725	*7.3*	20.4		73	4	B2	6.2	POL	7984	7006	46065	31.9
151														###											

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
152	161304900402	0	DF	DF	DF	10.0	MEI	14.0	LAR(	2	LTS	146	873	5.5	14.5		69	3	C2	8.6	POL	4315	3685	21143	9.5
153	161304900402	1	DF	DF	DF	10.0	MEI	14.0	LAR(	2	LTS	160	790	6.1	14.6		70	4	C2	9.6	MEI	4782	4203	24427	11.9
154	161304900402	2	DF	DF	DF	15.0	LAR	14.0	LAR(	2	LTS	184	643	7.3	15.1		72	4	C2	11.3	MEI	5729	5078	29284	12.9
155	161304900402	3	DF	DF	DF	15.0	LAR	14.0	LAR(	2	LTS	204	646	7.6	15.6		73	4	C2	12.8	MEI	6618	5876	33275	13.4
156	161304900402	4	DF	DF	DF	15.0	LAR	14.0	LAR(	2	LTS	219	521	8.8	16.2		73	4	C2	14.2	MEI	7417	6685	37953	14.6
157	161304900402	5	DF	DF	DF	15.0	LAR	14.0	LAR(	2	LTS	231	471	9.5	16.9		73	4	C2	14.9	MEI	8173	7367	42140	20.4
158	161304900402	6	DF	DF	DF	15.0	LAR	14.0	LAR(	2	LTS	242	383	10.8	17.5		73	4	C2	16.2	LAR	8884	8041	46421	18.1
159	161304900402	7	DF	DF	DF	15.0	LAR	14.0	LAR(	2	LTS	251	361	11.3	18.2		73	4	C2	17.1	LAR	9538	8674	50458	20.5
160	161304900402	8	DF	DF	DF	15.0	LAR	14.0	LAR(	2	LTS	259	297	12.6	18.9		72	4	C2	18.4	LAR	10162	9317	54783	22.3
161	161304900402	9	DF	DF	DF	15.0	LAR	14.0	LAR(	C	LMS	266	280	13.2	19.6		72	4	C2	19.8	LAR	10739	9892	58389	18.5
162	161304900402	10	DF	DF	DF	20.0	V-L	14.0	LAR(	C	LMS	272	235	14.6	20.3		71	4	C2	21.1	V-LA	11260	10391	62011	20.6
163	161304900402	11	DF	DF	DF	20.0	V-L	21.0	V-LA	C	VLM	277	242	14.5	21.0		70	4	C2	22.0	V-LA	11747	10825	65016	20.9
164	161304900402	12	DF	DF	DF	20.0	V-L	21.0	V-LA	C	VLM	282	204	15.9	21.7		70	4	C2	23.5	V-LA	12223	11277	68202	22.3
165	161304900402	13	DF	DF	DF	20.0	V-L	21.0	V-LA	C	VLM	286	219	15.5	22.3		69	3	C2	24.0	V-LA	12632	11722	71740	23.7
166														###											
167	161304900434	0	DF	DF	DF	15.0	LAR	14.0	LAR(	C	LMS	121	329	8.2	18.0		41	3	B2	17.8	LAR	4172	3793	21199	19.8
168	161304900434	1	DF	DF	DF	15.0	LAR	14.0	LAR(	C	LMS	126	303	8.7	18.3		42	3	B2	18.3	LAR	4401	3987	22264	19.2
169	161304900434	2	DF	DF	DF	15.0	LAR	14.0	LAR(	C	LMS	135	261	9.7	19.0		43	3	B2	19.5	LAR	4849	4425	25327	18.5
170	161304900434	3	DF	DF	DF	15.0	LAR	14.0	LAR(	C	LMS	144	368	8.5	19.7		45	3	B2	18.9	LAR	5272	4817	27837	19.6
171	161304900434	4	DF	DF	DF	20.0	V-L	14.0	LAR(	2	LTS	151	306	9.5	20.3		45	3	B2	20.8	LAR	5675	5182	30092	20.5
172	161304900434	5	DF	DF	DF	20.0	V-L	14.0	LAR(	2	LTS	158	309	9.7	20.9		46	3	B2	21.4	V-LA	6026	5513	32395	21.6
173	161304900434	6	DF	DF	DF	20.0	V-L	21.0	V-LA	2	VLTS	163	258	10.8	21.5		47	3	B2	22.2	V-LA	6352	5812	34631	23.2
174	161304900434	7	DF	DF	DF	20.0	V-L	21.0	V-LA	2	VLTS	168	312	9.9	22.1		47	3	B2	22.8	V-LA	6680	6117	36988	24.9
175	161304900434	8	DF	DF	DF	20.0	V-L	21.0	V-LA	C	VLM	173	259	11.1	21.7		48	3	B2	24.1	V-LA	6985	6372	38838	26.4
176	161304900434	9	DF	DF	DF	20.0	V-L	21.0	V-LA	C	VLM	178	293	10.6	21.3		48	3	B2	23.2	V-LA	7279	6594	40540	25.7
177	161304900434	10	DF	DF	DF	20.0	V-L	21.0	V-LA	C	VLM	183	243	11.8	21.7		49	3	B2	25.2	V-LA	7593	6940	43014	26.1
178	161304900434	11	DF	DF	DF	20.0	V-L	21.0	V-LA	C	VLM	187	291	10.9	21.8		49	3	B2	24.3	V-LA	7852	7182	44720	26.7
179	161304900434	12	DF	DF	DF	20.0	V-L	21.0	V-LA	C	VLM	191	239	12.1	22.1		50	3	B2	26.1	V-LA	8104	7469	47005	27.6
180	161304900434	13	DF	DF	DF	25.0	XX-	21.0	V-LA	C	VLM	195	294	11.0	22.0		50	3	B2	25.0	V-LA	8352	7704	48853	28.1
181														###											

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
182	161304900435	0	DF	DF	DF	5.0-	POL	5.0-	POLI	C	PMS	60.2	710	3.9	8.4		46	3	B2	7.4	POL	1273	779	4056	8.7
183	161304900435	1	DF	DF	DF	5.0-	POL	5.0-	POLI	C	PMS	64.8	655	4.3	8.7		47	3	B2	7.7	POL	1420	928	4726	11.0
184	161304900435	2	DF	DF	DF	5.0-	POL	9.0-	MEI	C	MMS	76.1	565	5.0	9.2		50	3	B2	8.6	POL	1767	1291	6747	11.9
185	161304900435	3	DF	DF	DF	5.0-	POL	9.0-	MEI	C	MMS	86.9	537	5.4	9.8		53	3	B2	9.2	MEI	2118	1571	8457	12.7
186	161304900435	4	DF	DF	DF	10.0	MEI	9.0-	MEI	C	MMS	96.9	468	6.2	10.3		54	3	B2	11.3	MEI	2472	1805	9370	13.3
187	161304900435	5	DF	DF	DF	10.0	MEI	9.0-	MEI	C	MMS	108	463	6.5	10.9		56	3	B2	11.9	MEI	2884	2151	11313	14.0
188	161304900435	6	DF	DF	DF	10.0	MEI	9.0-	MEI	C	MMS	118	410	7.3	11.5		57	3	B2	13.8	MEI	3266	2467	13187	14.3
189	161304900435	7	DF	DF	DF	10.0	MEI	9.0-	MEI	C	MMS	127	433	7.3	12.0		58	3	B2	13.5	MEI	3615	2791	15069	16.2
190	161304900435	8	DF	DF	DF	10.0	MEI	9.0-	MEI	C	MMS	135	381	8.1	12.6		59	3	B2	15.1	LAR	3955	3158	16816	15.7
191	161304900435	9	DF	DF	DF	10.0	MEI	9.0-	MEI	C	MMS	142	439	7.7	13.1		59	3	B2	14.4	MEI	4267	3451	18456	16.0
192	161304900435	10	DF	DF	DF	10.0	MEI	9.0-	MEI	C	MMS	149	379	8.5	13.7		59	3	B2	15.4	LAR	4584	3822	20791	16.7
193	161304900435	11	DF	DF	DF	10.0	MEI	14.0	LAR	1	LARC	156	432	8.1	14.3		60	3	B2	15.9	LAR	4931	4219	22976	17.4
194	161304900435	12	DF	DF	DF	10.0	MEI	14.0	LAR	1	LARC	164	371	9.0	14.8		60	3	B2	16.6	LAR	5263	4554	25082	17.9
195	161304900435	13	DF	DF	DF	15.0	LAR	14.0	LAR	1	LARC	170	381	9.0	15.4		60	3	B2	17.3	LAR	5565	4953	27405	18.2
196														###											
197	161304900436	0	DF	DF	DF	10.0	MEI	9.0-	MEI	1	MED	104	224	9.2	13.8		51	3	B2	13.0	MEI	3191	2605	14495	12.1
198	161304900436	1	DF	DF	DF	10.0	MEI	14.0	LAR	1	LARC	116	214	10.0	14.2		53	3	B2	14.1	MEI	3599	3066	16638	13.2
199	161304900436	2	DF	DF	DF	10.0	MEI	14.0	LAR	1	LARC	133	199	11.1	14.9		55	3	B2	15.6	LAR	4252	3810	21161	14.4
200	161304900436	3	DF	DF	DF	15.0	LAR	14.0	LAR	1	LARC	148	359	8.7	15.5		57	3	B2	14.9	MEI	4856	4376	24181	15.3
201	161304900436	4	DF	DF	DF	15.0	LAR	14.0	LAR	C	LMS	161	312	9.7	16.2		58	3	B2	16.1	LAR	5401	4897	27349	15.4
202	161304900436	5	DF	DF	DF	15.0	LAR	14.0	LAR	2	LTS	171	331	9.7	16.8		60	3	B2	16.7	LAR	5897	5324	29988	16.2
203	161304900436	6	DF	DF	DF	15.0	LAR	14.0	LAR	2	LTS	180	286	10.8	17.4		60	3	B2	17.9	LAR	6319	5758	32318	16.3
204	161304900436	7	DF	DF	DF	15.0	LAR	14.0	LAR	1	LARC	188	324	10.3	18.0		61	3	B2	18.9	LAR	6750	6190	35035	17.6
205	161304900436	8	DF	DF	DF	15.0	LAR	14.0	LAR	1	LARC	196	279	11.4	18.4		61	3	B2	19	LAR	7166	6551	36944	17.5
206	161304900436	9	DF	DF	DF	15.0	LAR	14.0	LAR	1	LARC	204	303	11.1	19.1		62	3	B2	19.1	LAR	7582	6957	40080	18.2
207	161304900436	10	DF	DF	DF	15.0	LAR	14.0	LAR	1	LARC	210	259	12.2	19.9		62	3	B2	20	LAR	7948	7275	41899	19.0
208	161304900436	11	DF	DF	DF	20.0	V-L	14.0	LAR	1	LARC	215	331	10.9	20.5		62	3	B2	20.8	LAR	8286	7624	44387	
209	161304900436	12	DF	DF	DF	20.0	V-L	14.0	LAR	1	LARC	221	276	12.1	20.9		62	3	B2	21.4	LAR	8648	7949	46496	
210	161304900436	13	DF	DF	DF	20.0	V-L	21.0	V-L	1	VLAI	225	333	11.1			62	3	B2		LAR	8944	8238	48688	
211														###											

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
212	161304900438	0	AF-DF	DF-AF	AF	10.0	ME	9.0-	MEI	2	MTS	81.3	3558	2.0	12.9		42	3	F1	0.5	SS	2062	1622	8449	11.8
213	161304900438	1	AF-DF	DF-AF	AF	10.0	ME	9.0-	MEI	C	MMS	88.8	3292	2.2	12.8		46	3	F1	0.9	SS	2259	1781	9286	14.4
214	161304900438	2	AF-DF	DF-AF	AF	10.0	ME	9.0-	MEI	C	MMS	106	2819	2.6	12.6		53	3	F1	1.8	SS	2697	2009	10636	11.4
215	161304900438	3	AF-DF	DF-AF	AF	10.0	ME	9.0-	MEI	C	MMS	127	2678	2.9	12.5		60	3	F1	2.7	SS	3198	2457	13064	10.5
216	161304900438	4	AF-DF	DF-AF	AF	10.0	ME	9.0-	MEI	2	MTS	147	2289	3.4	12.0		64	3	F1	4.9	SS	3716	2902	15029	9.4
217	161304900438	5	AF-DF	DF-AF	AF	10.0	ME	9.0-	MEI	2	MTS	167	2135	3.8	11.8		67	3	F1	5.3	POL	4232	3332	17665	10.2
218	161304900438	6	AF	AF	AF	10.0	ME	9.0-	MEI	2	MTS	186	1815	4.3	11.6		69	3	F1	7.2	POL	4765	3689	19825	10.6
219	161304900438	7	AF	AF	AF	10.0	ME	9.0-	MEI	C	MMS	202	1721	4.6	11.9		69	3	F1	8.0	POL	5262	4078	21874	11.1
220	161304900438	8	AF	AF	AF	10.0	ME	9.0-	MEI	C	MMS	214	1432	5.2	12.1		68	3	F1	8.8	POL	5728	4468	23932	11.7
221	161304900438	9	AF	AF	AF	10.0	ME	9.0-	MEI	C	MMS	222	1427	5.3	12.4		67	3	F1	9.4	MEI	6155	4830	25816	12.1
222	161304900438	10	AF	AF	AF	10.0	ME	9.0-	MEI	C	MMS	229	1185	6.0	12.8		66	3	F1	10.2	MEI	6593	5136	27360	12.6
223	161304900438	11	AF	AF	AF	10.0	ME	9.0-	MEI	C	MMS	234	1328	5.7	13.3		64	3	F1	10.2	MEI	7003	5599	30402	13.0
224	161304900438	12	AF	AF	AF	10.0	ME	9.0-	MEI	2	MTS	238	1095	6.3	13.8		63	3	F1	11.3	MEI	7412	5967	32812	13.6
225	161304900438	13	AF	AF	AF	10.0	ME	14.0	LAR	2	LTS	242	1149	6.2	14.0		62	3	F1	11.5	MEI	7829	6325	34770	14.5
226														###											
227	161304900439	0	AF	AF	AF	10.0	ME	9.0-	MEI	2	MTS	138	2443	3.2	11.9		57	3	F1	4.1	SS	3821	2898	15842	11.2
228	161304900439	1	AF	AF	AF	10.0	ME	9.0-	MEI	2	MTS	153	2259	3.5	12.0		59	3	F1	4.6	SS	4226	3143	17742	15.2
229	161304900439	2	AF	AF	AF	10.0	ME	9.0-	MEI	2	MTS	184	1934	4.2	12.3		62	3	F1	7.2	POL	5089	3986	22097	9.3
230	161304900439	3	AF	AF	AF	10.0	ME	9.0-	MEI	2	MTS	210	1803	4.6	12.7		64	3	F1	7.8	POL	5888	4639	25433	9.8
231	161304900439	4	AF	AF	AF	10.0	ME	9.0-	MEI	2	MTS	232	1527	5.3	13.0		65	3	F1	9.0	MEI	6612	5187	28685	10.9
232	161304900439	5	AF	AF	AF	10.0	ME	9.0-	MEI	C	MMS	251	1484	5.6	13.4		66	3	F1	9.3	MEI	7282	5642	31251	11.7
233	161304900439	6	AF	AF	AF	10.0	ME	9.0-	MEI	C	MMS	267	1251	6.3	13.8		65	3	F1	10.4	MEI	7940	6306	34892	13.0
234	161304900439	7	AF	AF	AF	10.0	ME	14.0	LAR	C	LMS	280	1267	6.4	14.1		65	3	F1	10.4	MEI	8528	6829	37357	13.6
235	161304900439	8	AF	AF	AF	10.0	ME	14.0	LAR	C	LMS	291	1061	7.1	14.5		64	3	F1	12.1	MEI	9111	7557	41871	13.5
236	161304900439	9	AF	AF	AF	15.0	LAR	14.0	LAR	C	LMS	300	1205	6.8	14.5		64	3	F1	11.8	MEI	9642	8154	45164	14.8
237	161304900439	10	AF	AF	AF	15.0	LAR	14.0	LAR	C	LMS	306	1001	7.5	14.7		63	3	F1	12.8	MEI	10146	8719	48752	15.1
238	161304900439	11	AF	AF	AF	15.0	LAR	14.0	LAR	C	LMS	311	1107	7.2	14.7		62	3	F1	12.4	MEI	10626	9180	50692	15.4
239	161304900439	12	AF	AF	AF	15.0	LAR	14.0	LAR	2	LTS	318	913	8.0	14.7		61	3	F1	14.1	MEI	11138	9730	54168	15.1
240	161304900439	13	AF	AF	AF	15.0	LAR	14.0	LAR	2	LTS	323	1047	7.5	14.7		60	3	F1	13.7	MEI	11635	10214	57091	15.1
241														###											

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
242	161304900469	0	LP	LP	LP	5.0-	POL	9.0-	MEL	C	MMS	113	2050	3.2	9.4		54	3	C1	6.1	POL	2991	2352	12248	9.9
243	161304900469	1	LP	LP	LP	5.0-	POL	9.0-	MEL	C	MMS	122	1804	3.5	9.6		55	3	C1	6.5	POL	3312	2587	13289	10.0
244	161304900469	2	LP	LP	LP	10.0	MEI	9.0-	MEL	C	MMS	138	1405	4.2	10.2		57	3	C1	8.3	POL	3957	3168	16335	11.3
245	161304900469	3	LP	LP	LP	10.0	MEI	9.0-	MEL	C	MMS	151	1125	5.0	10.8		59	3	C1	9.6	MEL	4537	3643	18533	12.2
246	161304900469	4	LP	LP	LP	10.0	MEI	9.0-	MEL	C	MMS	163	886	5.8	11.4		60	3	C1	10.9	MEL	5106	4241	21567	12.5
247	161304900469	5	LP	LP	LP	10.0	MEI	9.0-	MEL	C	MMS	172	761	6.4	12.0		60	3	C1	11.7	MEL	5610	4735	24809	12.7
248	161304900469	6	LP	LP	LP	10.0	MEI	9.0-	MEL	C	MMS	179	615	7.3	12.6		60	3	C1	13.0	MEL	6071	5237	28070	13.2
249	161304900469	7	LP	LP	LP	10.0	MEI	9.0-	MEL	C	MMS	185	575	7.7	13.2		59	3	C1	13.5	MEL	6481	5700	30072	14.4
250	161304900469	8	LP	LP	LP	10.0	MEI	9.0-	MEL	C	MMS	190	468	8.6	13.8		59	3	C1	14.9	MEL	6891	6101	32760	15.9
251	161304900469	9	LP-DF	DF-LP	LP	10.0	MEI	14.0	LAR	C	LMS	193	530	8.2	14.3		58	3	C1	15.0	LAR	7236	6442	34875	16.3
252	161304900469	10	LP-DF	DF-LP	LP	10.0	MEI	14.0	LAR	C	LMS	196	426	9.2	14.9		57	3	C1	16.3	LAR	7553	6797	37235	16.8
253	161304900469	11	LP-DF	DF-LP	LP	15.0	LAR	14.0	LAR	C	LMS	196	495	8.5	15.5		56	3	C1	16.0	LAR	7764	6980	38566	17.4
254	161304900469	12	LP-DF	DF-LP	LP	15.0	LAR	14.0	LAR	C	LMS	197	384	9.7	16.1		55	3	C1	17.2	LAR	8012	7210	40145	18.1
255	161304900469	13	LP-DF	DF-LP	LP	15.0	LAR	14.0	LAR	C	LMS	196	429	9.2	16.6		54	3	C1	17.0	LAR	8177	7386	41192	18.5
256														###											
257	161304900470	0	ES	ES	ES	20.0	V-L	21.0	V-LA	C	VLM	226	950	6.6	22.0		46	3	D3	6.2	POL	9789	8632	52351	25.9
258	161304900470	1	ES	ES	ES	20.0	V-L	21.0	V-LA	C	VLM	231	828	7.1	22.3		46	3	D3	12.4	MEL	10061	8886	54226	24.9
259	161304900470	2	ES	ES	ES	20.0	V-L	21.0	V-LA	2	VLTS	241	638	8.3	22.7		46	3	D3	14.1	MEL	10627	9413	57684	24.3
260	161304900470	3	ES	ES	ES	20.0	V-L	21.0	V-LA	2	VLTS	250	827	7.4	23.1		47	3	D3	13.0	MEL	11128	10080	61793	25.0
261	161304900470	4	ES	ES	ES	20.0	V-L	21.0	V-LA	C	VLM	259	630	8.7	23.6		47	3	D3	14.8	MEL	11661	10559	65519	26.7
262	161304900470	5	ES	ES	ES	20.0	V-L	21.0	V-LA	C	VLM	267	781	7.9	24.0		47	3	D3	14.0	MEL	12151	11074	69063	27.4
263	161304900470	6	ES	ES	ES	20.0	V-L	21.0	V-LA	2	VLTS	277	602	9.2	24.3		47	3	D3	16.1	LAR	12676	11556	72497	27.9
264	161304900470	7	ES	ES	ES	20.0	V-L	21.0	V-LA	C	VLM	287	790	8.2	24.7		48	3	D3	11.1	MEL	13196	12071	76086	32.8
265	161304900470	8	ES	ES	ES	25.0	XX-	21.0	V-LA	C	VLM	296	592	9.6	25.1		48	3	D3	17.1	LAR	13688	12551	79144	32.7
266	161304900470	9	ES	ES	ES	25.0	XX-	21.0	V-LA	C	VLM	301	808	8.3	25.4		48	3	D3	13.8	MEL	14102	12934	81921	33.3
267	161304900470	10	ES	ES	ES	25.0	XX-	21.0	V-LA	2	VLTS	308	595	9.7	25.8		47	3	D3	16.4	LAR	14560	13370	85037	33.9
268	161304900470	11	ES	ES	ES	25.0	XX-	21.0	V-LA	2	VLTS	313	692	9.1	26.1		47	3	D3	15.6	LAR	14941	13731	87558	34.1
269	161304900470	12	ES	ES	ES	25.0	XX-	21.0	V-LA	2	VLTS	318	509	10.7	26.3		47	3	D3	18.1	LAR	15386	14170	91125	35.0
270	161304900470	13	ES	ES	ES	25.0	XX-	21.0	V-LA	2	VLTS	321	747	8.9	26.6		47	3	D3	14.5	LAR	15737	14511	93559	35.8
271														###											

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
272	161304900471	0	DF	DF	DF	20.0	V-L	21.0	V-LA	1	VLAI	120	225	9.9	24.1		37	2	B2	21.2	V-LA	4454	4080	24338	24.6
273	161304900471	1	DF	DF	DF	20.0	V-L	21.0	V-LA	1	VLAI	122	201	10.6	24.4		37	2	B2	22.0	V-LA	4579	4232	25454	24.1
274	161304900471	2	DF	DF	DF	20.0	V-L	21.0	V-LA	1	VLAI	126	168	11.7	24.9		38	2	B2	24.1	V-LA	4804	4439	26828	24.6
275	161304900471	3	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAI	130	270	9.4	25.5		39	2	B2	20.7	LAR	5023	4648	28439	24.8
276	161304900471	4	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAI	135	219	10.6	26.1		40	3	B2	22.9	V-LA	5291	4884	30091	26.0
277	161304900471	5	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAI	140	253	10.1	26.6		40	3	B2	22.8	V-LA	5546	5135	31934	25.9
278	161304900471	6	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAI	144	205	11.4	27.1		41	3	B2	24.5	V-LA	5805	5377	33693	26.5
279	161304900471	7	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAI	148	235	10.8	27.7		42	3	B2	23.9	V-LA	6038	5591	35356	27.6
280	161304900471	8	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAI	153	191	12.1	28.2		42	3	B2	26.4	V-LA	6286	5832	37166	28.0
281	161304900471	9	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAI	157	223	11.3	28.7		43	3	B2	25.1	V-LA	6520	6045	38634	29.1
282	161304900471	10	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAI	160	180	12.8	29.3		43	3	B2	27.7	V-LA	6746	6236	40192	29.7
283	161304900471	11	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAI	164	240	11.2	29.8		43	3	B2	24.8	V-LA	6947	6425	41647	30.0
284	161304900471	12	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAI	167	191	12.7	30.3		44	3	B2	28.0	V-LA	7168	6640	43391	31.1
285	161304900471	13	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAI	170	259	11.0	30.8		44	3	B2	24.6	V-LA	7355	6822	44911	31.7
286														###											
287	161304900472	0	DF	DF	DF	20.0	V-L	14.0	LAR	C	LMS	160	276	10.3	20.7		51	3	B2	20.6	LAR	5880	5422	31548	22.0
288	161304900472	1	DF	DF	DF	20.0	V-L	14.0	LAR	C	LMS	163	253	10.9	20.9		50	3	B2	21.1	V-LA	6051	5567	32515	22.6
289	161304900472	2	DF	DF	DF	20.0	V-L	21.0	V-LA	C	VLM	168	214	12.0	21.5		51	3	B2	22.3	V-LA	6365	5868	34184	22.4
290	161304900472	3	DF	DF	DF	20.0	V-L	21.0	V-LA	1	VLAI	172	297	10.3	22.0		51	3	B2	21.4	V-LA	6599	6090	35926	22.9
291	161304900472	4	DF	DF	DF	20.0	V-L	21.0	V-LA	1	VLAI	175	240	11.6	22.5		51	3	B2	22.8	V-LA	6831	6298	37334	23.2
292	161304900472	5	DF	DF	DF	20.0	V-L	21.0	V-LA	1	VLAI	178	239	11.7	23.0		51	3	B2	23.3	V-LA	7024	6487	38858	24.6
293	161304900472	6	DF	DF	DF	20.0	V-L	21.0	V-LA	1	VLAI	180	195	13.0	23.4		51	3	B2	24.4	V-LA	7189	6646	39804	25.1
294	161304900472	7	DF	DF	DF	20.0	V-L	21.0	V-LA	1	VLAI	180	217	12.3	23.8		50	3	B2	24.3	V-LA	7311	6772	41203	27.4
295	161304900472	8	DF	DF	DF	20.0	V-L	21.0	V-LA	1	VLAI	181	176	13.7	24.2		50	3	B2	25.3	V-LA	7435	6879	42253	26.5
296	161304900472	9	DF	DF	DF	20.0	V-L	21.0	V-LA	1	VLAI	182	205	12.7	24.6		49	3	B2	25.1	V-LA	7542	7008	43412	26.3
297	161304900472	10	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAI	182	165	14.2	25.0		49	3	B2	26.0	V-LA	7655	7103	44171	26.5
298	161304900472	11	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAI	182	203	12.8	25.4		48	3	B2	25.7	V-LA	7740	7176	44797	26.3
299	161304900472	12	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAI	184	161	14.5	25.8		48	3	B2	28.1	V-LA	7892	7302	45967	26.8
300	161304900472	13	DF	DF	DF	25.0	XX-	21.0	V-LA	1	VLAI	185	207	12.8	26.2		48	3	B2	26.1	V-LA	8036	7484	47544	27.0
301														###											

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
302	161304900473	0	DF-LP	DF-LP	DF	5.0-	POL	5.0-	POLI	C	PMS	99.5	2141	2.9	8.8		62	3	B3	4.9	SS	1999	1463	6769	7.5
303	161304900473	1	DF-LP	DF-LP	DF	5.0-	POL	5.0-	POLI	C	PMS	103	1907	3.2	8.9		62	3	B3	4.1	SS	2121	1588	7809	9.2
304	161304900473	2	DF-LP	DF-LP	DF	5.0-	POL	9.0-	MED	C	MMS	111	1523	3.7	9.2		63	3	B3	7.9	POL	2378	1805	8781	9.9
305	161304900473	3	DF-LP	DF-LP	DF	5.0-	POL	9.0-	MED	C	MMS	119	1273	4.1	9.5		64	3	B3	8.9	POL	2657	1976	9455	10.6
306	161304900473	4	DF-LP	DF-LP	DF	5.0-	POL	9.0-	MED	C	MMS	125	1037	4.7	9.9		64	3	B3	9.7	MED	2886	2167	10454	10.9
307	161304900473	5	DF-LP	DF-LP	DF	10.0	MED	9.0-	MED	C	MMS	128	895	5.1	10.3		64	3	B3	10.2	MED	3076	2318	11041	11.1
308	161304900473	6	DF-LP	DF-LP	DF	10.0	MED	9.0-	MED	C	MMS	130	730	5.7	10.8		63	3	B3	10.7	MED	3231	2408	11761	11.8
309	161304900473	7	DF-LP	DF-LP	DF	10.0	MED	9.0-	MED	C	MMS	131	755	5.6	11.2		62	3	B3	10.9	MED	3380	2548	12722	12.4
310	161304900473	8	DF-LP	DF-LP	DF	10.0	MED	9.0-	MED	C	MMS	133	615	6.3	11.6		61	3	B3	11.8	MED	3532	2664	13559	12.9
311	161304900473	9	DF-LP	DF-LP	DF	10.0	MED	9.0-	MED	C	MMS	134	610	6.4	12.1		60	3	B3	12.1	MED	3673	2810	14489	13.6
312	161304900473	10	DF-LP	DF-LP	DF	10.0	MED	9.0-	MED	C	MMS	136	496	7.1	12.5		59	3	B3	12.9	MED	3841	2964	15330	14.0
313	161304900473	11	DF-LP	DF-LP	DF	10.0	MED	9.0-	MED	C	MMS	138	543	6.8	13.0		59	3	B3	13.1	MED	4007	3210	16605	14.7
314	161304900473	12	DF-LP	DF-LP	DF	10.0	MED	9.0-	MED	C	MMS	141	440	7.7	13.4		58	3	B3	14.0	MED	4180	3494	18362	15.5
315	161304900473	13	DF-LP	DF-LP	DF	10.0	MED	9.0-	MED	C	MMS	142	584	6.7	13.9		58	3	B3	13.4	MED	4322	3725	19918	15.6
316														###											
317	161304900474	0	AF	AF	AF	5.0-	POL	5.0-	POLI	C	PMS	43.7	2618	1.8	8.4		25	2	F1	0.5	SS	741	425	1884	9.9
318	161304900474	1	AF	AF	AF	5.0-	POL	5.0-	POLI	C	PMS	48	2438	1.9	8.4		30	2	F1	1.1	SS	843	444	1881	5.8
319	161304900474	2	AF	AF	AF	5.0-	POL	5.0-	POLI	C	PMS	61.2	2117	2.3	8.0		42	3	F1	4.0	SS	1103	549	2564	5.7
320	161304900474	3	AF	AF	AF	5.0-	POL	5.0-	POLI	C	PMS	85.2	1925	2.8	7.3		55	3	F1	5.2	POL	1495	621	3216	6.1
321	161304900474	4	AF	AF	AF	5.0-	POL	5.0-	POLI	C	PMS	117	1745	3.5	6.8		64	3	F1	6.1	POL	2011	934	4649	5.9
322	161304900474	5	AF	AF	AF	5.0-	POL	5.0-	POLI	C	PMS	150	1696	4.0	6.8		69	3	F1	6.9	POL	2552	1276	6829	6.1
323	161304900474	6	AF	AF	AF	5.0-	POL	5.0-	POLI	C	PMS	167	1494	4.5	6.9		71	4	F1	7.3	POL	2954	1596	8796	6.2
324	161304900474	7	AF	AF	AF	5.0-	POL	5.0-	POLI	2	PTS	173	1592	4.5	7.1		70	4	F1	7.6	POL	3248	1689	8928	6.2
325	161304900474	8	AF	AF	AF	5.0-	POL	5.0-	POLI	2	PTS	176	1322	4.9	7.3		68	3	F1	8.1	POL	3495	1882	9868	6.9
326	161304900474	9	AF	AF	AF	5.0-	POL	5.0-	POLI	C	PMS	177	1371	4.9	7.4		66	3	F1	8.5	POL	3751	2038	10912	7
327	161304900474	10	AF	AF	AF	5.0-	POL	5.0-	POLI	C	PMS	181	1156	5.4	8.7		65	3	F1	8.8	POL	4068	2242	11920	7.3
328	161304900474	11	AF	AF	AF	5.0-	POL	9.0-	MED	C	MMS	187	1198	5.3	8.8		64	3	F1	8.8	POL	4397	2491	12898	7.5
329	161304900474	12	AF	AF	AF	5.0-	POL	9.0-	MED	C	MMS	192	1024	5.9	9.0		63	3	F1	9.0	MED	4761	2983	15998	8.2
330	161304900474	13	AF	AF	AF	5.0-	POL	9.0-	MED	4	MED	195	1121	5.6	9.0		63	3	F1	9.0	MED	5061	3238	17354	8.2
331														###											

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
332	161304900502	0	DF	DF	DF	10.0	ME	9.0-	MEI	C	MMS	158	2715	3.3	10.1		77	4	F1	4.4	SS	3056	2082	10249	12.1
333	161304900502	1	DF	DF	DF	10.0	ME	9.0-	MEI	C	MMS	166	2523	3.5	10.3		78	4	F1	4.7	SS	3329	2319	11698	14.2
334	161304900502	2	DF	DF	DF	10.0	ME	9.0-	MEI	C	MMS	183	2171	3.9	10.7		79	4	F1	5.7	POL	3913	2784	13436	14.5
335	161304900502	3	DF	DF	DF	10.0	ME	9.0-	MEI	C	MMS	198	2073	4.2	11.2		79	4	F1	6.3	POL	4504	3300	16040	15.3
336	161304900502	4	DF	DF	DF	10.0	ME	9.0-	MEI	C	MMS	213	1777	4.7	11.8		79	4	F1	7.6	POL	5156	3860	19462	15.8
337	161304900502	5	DF	DF	DF	10.0	ME	9.0-	MEI	C	MMS	226	1665	5.0	12.3		79	4	F1	8.6	POL	5796	4491	22917	16.3
338	161304900502	6	DF	DF	DF	10.0	ME	9.0-	MEI	C	MMS	237	1422	5.5	12.9		79	4	F1	9.6	MEI	6398	5104	25989	17.1
339	161304900502	7	DF	DF	DF	10.0	ME	9.0-	MEI	C	MMS	248	1403	5.7	13.4		78	4	F1	10.0	MEI	7004	5825	30390	17.2
340	161304900502	8	DF	DF	DF	10.0	ME	9.0-	MEI	1	MED	258	1183	6.3	13.9		78	4	F1	11.7	MEI	7641	6537	34720	17.6
341	161304900502	9	DF	DF	DF	10.0	ME	14.0	LAR	1	LAR	265	1188	6.4	14.4		77	4	F1	11.8	MEI	8179	7040	37834	17.9
342	161304900502	10	DF-LP	DF-LP	DF	10.0	ME	14.0	LAR	1	LAR	271	995	7.1	15.0		76	4	F1	13.6	MEI	8712	7637	40718	18.2
343	161304900502	11	DF-LP	DF-LP	DF	15.0	LAR	14.0	LAR	1	LAR	276	1080	6.8	15.5		75	4	F1	13.2	MEI	9183	8124	43734	18.5
344	161304900502	12	DF-LP	DF-LP	DF	15.0	LAR	14.0	LAR	C	LMS	281	892	7.6	16.0		74	4	F1	14.6	MEI	9678	8637	47190	19.1
345	161304900502	13	DF-LP	DF-LP	DF	15.0	LAR	14.0	LAR	C	LMS	286	986	7.3	16.6		73	4	F1	14.2	MEI	10164	9075	49907	19.5
346														###											
347	161304900503	0	LP	LP	LP	5.0-	POI	5.0-	POL	C	PMS	267	1777	5.2	7.0		62	3	C1	7.7	POL	9030	5690	33060	7.9
348	161304900503	1	LP	LP	LP	5.0-	POI	5.0-	POL	C	PMS	250	1529	5.5	7.3		59	3	C1	8.0	POL	8672	5699	32417	8.7
349	161304900503	2	LP	LP	LP	5.0-	POI	5.0-	POL	C	PMS	228	1160	6.0	7.8		54	3	C1	8.7	POL	8230	6008	33444	9.3
350	161304900503	3	LP	LP	LP	5.0-	POI	5.0-	POL	C	PMS	213	983	6.3	8.3		51	3	C1	9.2	MEI	7984	6251	34936	9.8
351	161304900503	4	LP	LP	LP	5.0-	POI	5.0-	POL	1	POL	204	783	6.9	8.9		48	3	C1	9.8	MEI	7909	6334	35523	10.6
352	161304900503	5	LP	LP	LP	5.0-	POI	9.0-	MEI	1	MED	198	758	6.9	9.4		46	3	C1	10.1	MEI	7895	6596	36463	11.6
353	161304900503	6	LP	LP	LP	5.0-	POI	9.0-	MEI	1	MED	194	614	7.6	9.9		45	3	C1	10.9	MEI	7934	6819	36881	12.0
354	161304900503	7	LP	LP	LP	10.0	ME	9.0-	MEI	1	MED	190	640	7.4	10.3		45	3	C1	11.1	MEI	7956	6929	37248	11.4
355	161304900503	8	LP	LP	LP	10.0	ME	9.0-	MEI	1	MED	188	513	8.2	10.7		44	3	C1	11.8	MEI	8022	7051	38207	10.8
356	161304900503	9	LP	LP	LP	10.0	ME	9.0-	MEI	1	MED	184	606	7.5	11.1		43	3	C1	12.0	MEI	8035	7186	39117	12.0
357	161304900503	10	LP	LP	LP	10.0	ME	9.0-	MEI	1	MED	185	482	8.4	11.5		43	3	C1	13.0	MEI	8201	7345	40002	13.3
358	161304900503	11	LP	LP	LP	10.0	ME	9.0-	MEI	1	MED	184	558	7.8	11.9		43	3	C1	13.3	MEI	8313	7530	40812	13.6
359	161304900503	12	LP	LP	LP	10.0	ME	9.0-	MEI	1	MED	185	435	8.8	12.6		43	3	C1	14.1	MEI	8533	7695	42091	14.3
360	161304900503	13	LP	LP	LP	10.0	ME	14.0	LAR	1	LAR	185	521	8.1	12.9		43	3	C1	14.5	MEI	8696	7953	43979	14.8
361														###											

The University of Montana

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December 16, 2005

J. Greg Jones
Technical Representative
USDA Forest Service
Rocky Mountain Research Station
800 E. Beckwith
Missoula, MT 59807

Dear Greg:

Enclosed please find three (3) copies of the final contract report for RJVA No. 03-JV-112222052-096. Please note there are four (4) sections, listed as follows:

Final RJVA Summary Report – 6 pages
Appendix A – Twer M.S. Thesis – 105 pages
Appendix B – Historic and predicted fires – 12 pages and maps
Appendix C – Using Bitterroot FIA/FUS to test SIMPPLLE Pathway – 33 pages

We are also putting all this on a CD and plan to put the other databases on an archive CD.

Thanks for your patience!

Robert D. Pfister
Emeritus Research Professor

cc: Perry Brown
Pat Bristol

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